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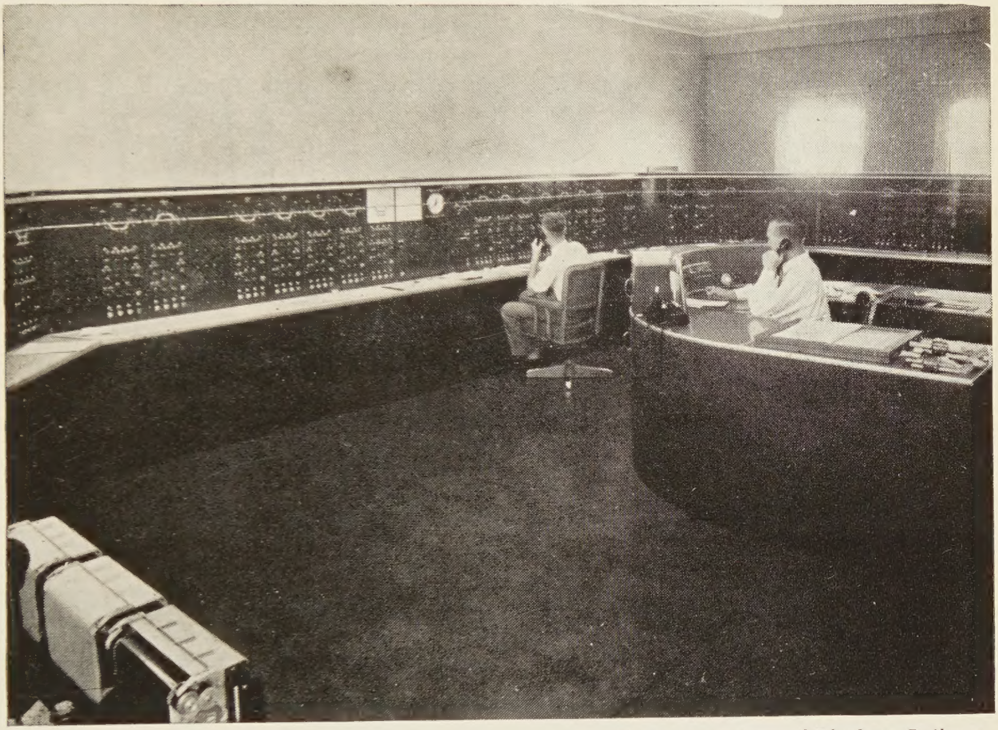

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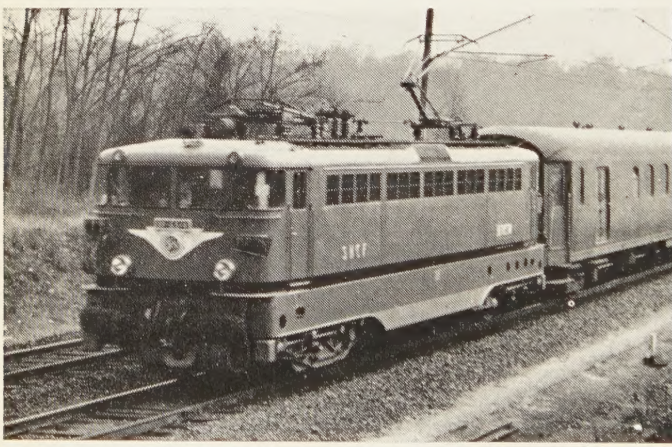

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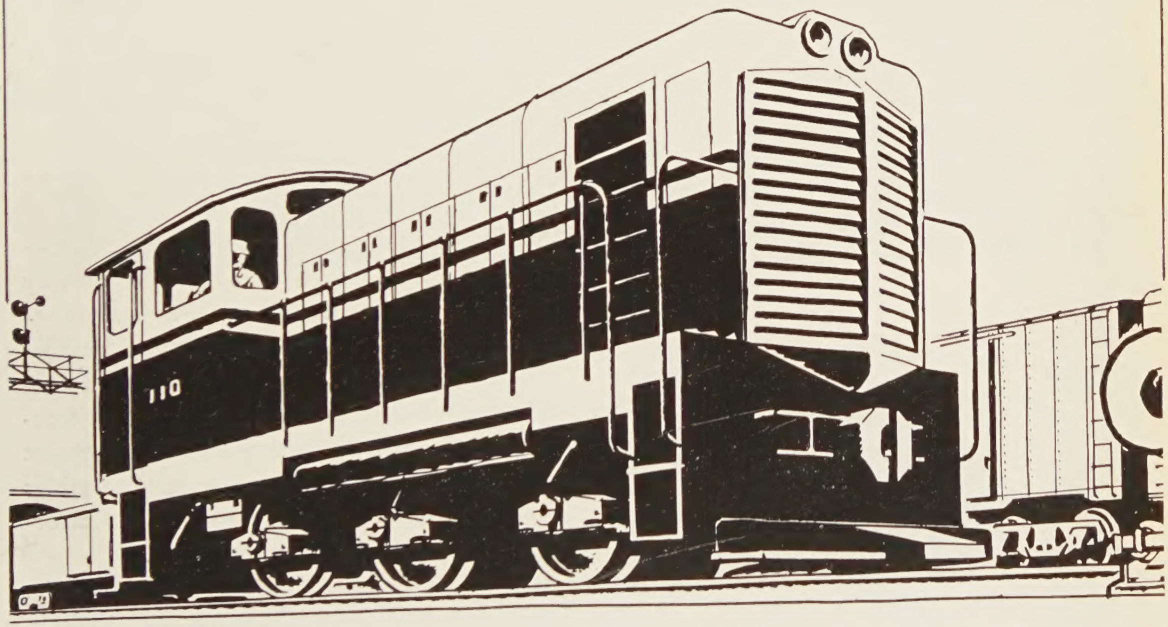

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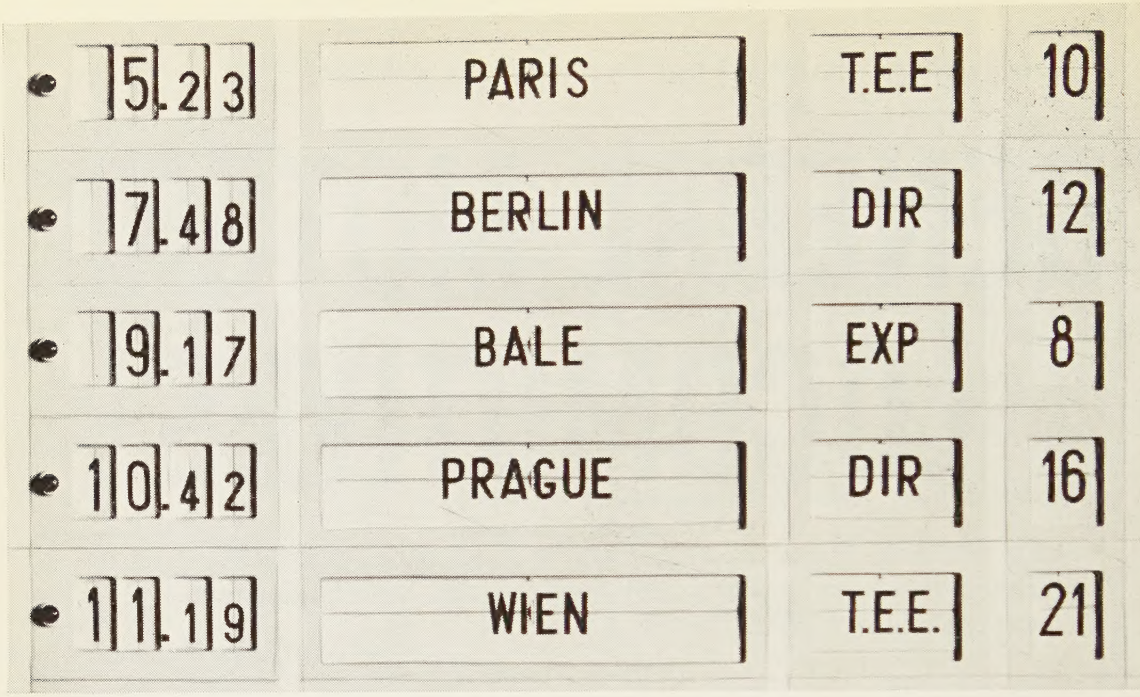

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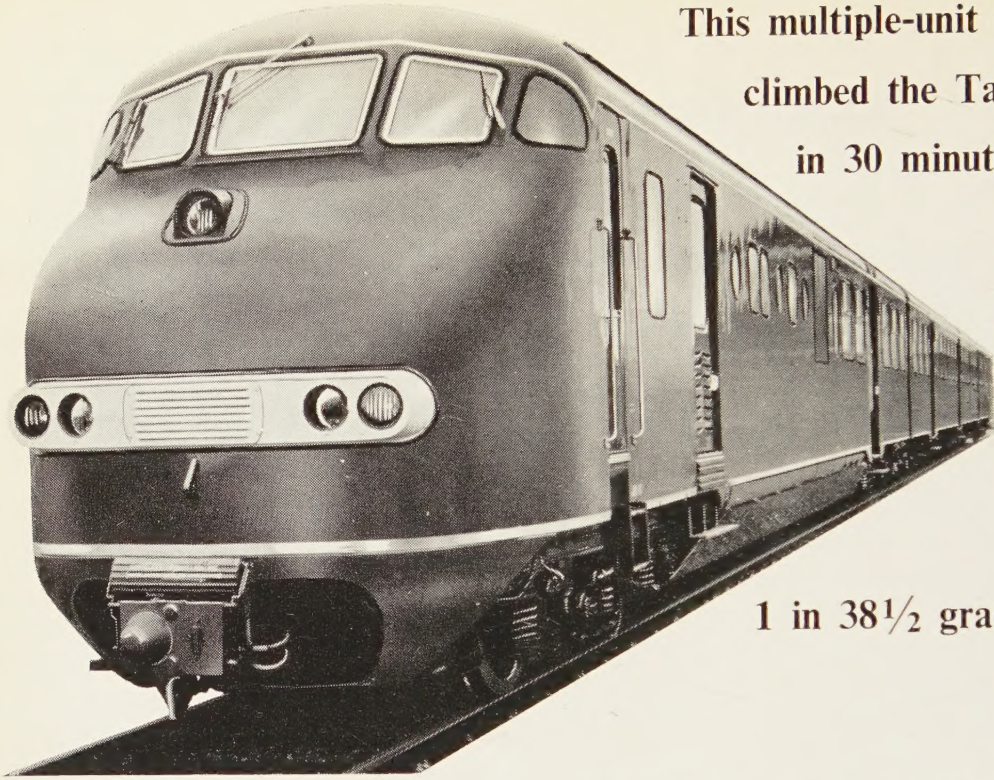

This multiple-unit train climbed the Tauern in 30 minutes...

1 in 38½ gradient

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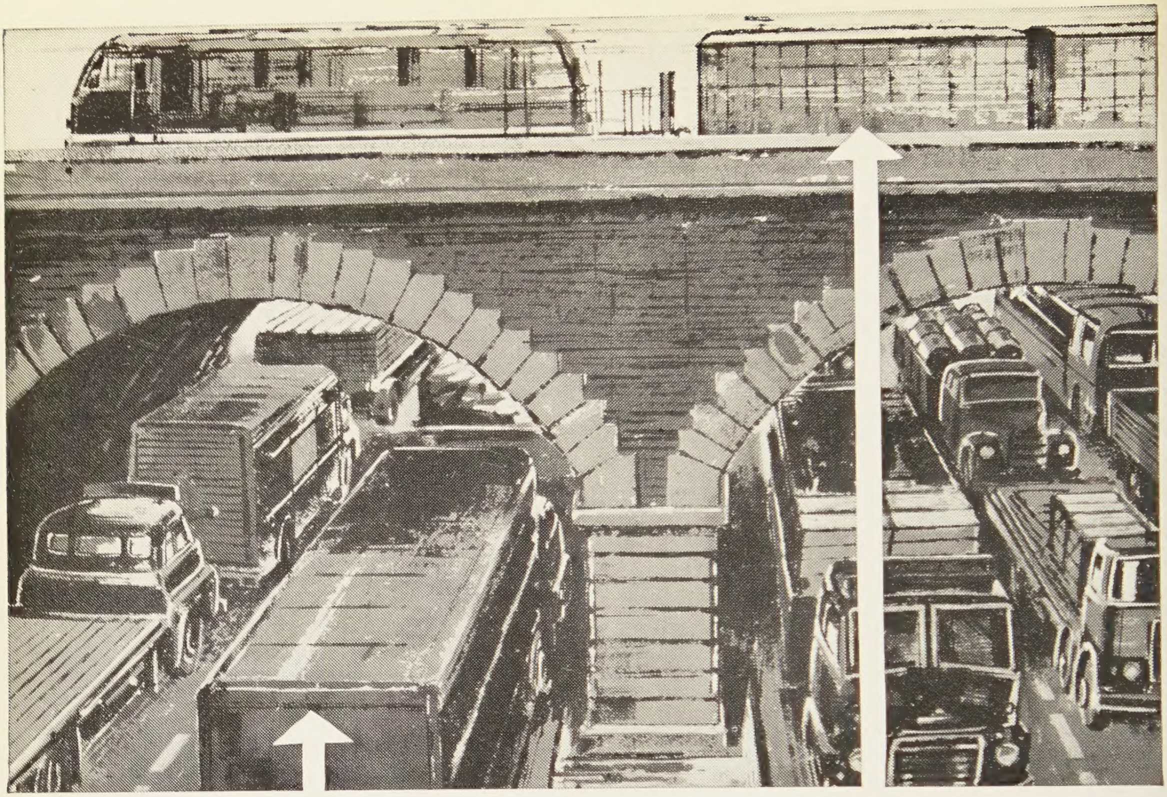

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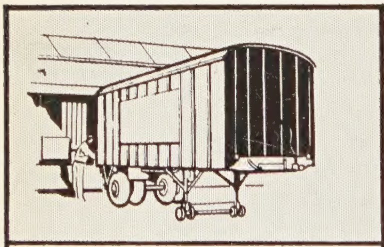
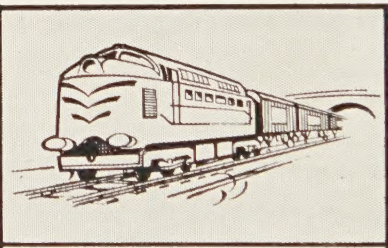
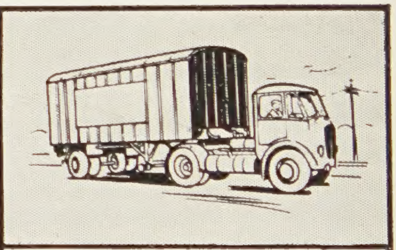


1 **The Roadrailer, loaded at the factory as an ordinary articulated lorry.**



2 **The Roadrailer as part of a fast freight train.**



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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

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The stability of long welded rails,

by D. L. Bartlett, B.Sc.(Eng.), F.G.S.

Assistant Director of Research (Engineering), Research Department, British Railways, Derby*

(*Civil Engineering and Public Works Review*, August, September, October, December 1960.)

Although experimental long rails had been installed before 1939 by the former main line Railway Companies, the serious installation of long welded rails prior to 1953 was confined to the then London Passenger Transport Board, which installed 300ft rails in its tunnels from 1936 onwards, subsequently adopting its present standard of half mile lengths in the open. Valuable theoretical and experimental work on the subject of long welded rail stability was also carried out by London Transport during this period.

Differences between British and Continental track standards and traffic conditions made it highly desirable that,whilst taking full cognisance of developments elsewhere, British Railways should investigate carefully the conditions requisite to ensure stability.

On behalf of the Civil Engineering Committee of British Railways, Mr. M. G. R. Smith, Chief Civil Engineer of the Western Region, undertook to carry out such investigations. This article describes these investigations together with the complementary studies made by the Research Department of British Railways.

It was felt that the answers to this problem would best be produced by :

(*a*) a series of field trials involving the installation of long welded lengths and using these field trails to obtain information on the practical aspects of laying, maintenance, methods of welding, etc.;

(*b*) field measurements on long welded lengths from the aspects of movements and temperatures; and

(*c*) laboratory tests to investigate basic problems such as resistance to buckling and to creep and expansion. Where possible the tests were accelerated to produce information in a short time in the Laboratory which might take many years to produce from the track.

Field trials.

It is not basically the purpose of this paper to discuss at any great length the field trials mentioned in (*a*). In the knowledge gained by these studies the installation of long welded rails on British Railways has proceeded. About 240 miles of long welded rails have been laid in of which some 70 miles are located in the Western Region.

(*a*) *Installation.*

As a result of both field trials and measurements and laboratory tests, instructions governing the laying and maintenance of long welded rails have been drawn up.

In general the practice of laying such rails has been to weld standard rails into 300 ft lengths in a Depot and, after laying, to site

* Formerly Head of Civil Engineering Laboratory, British Railways (Western Region).

weld these into continuous lengths. The later depots are equipped to weld into 600 ft and 900 ft lengths.

Flash butt welding is used for the depot work and Thermit or Philips E.W. welding for in situ work. The quick thermit process is superseding the normal thermit welding, since it gives more consistent welds.

Fig. 1. — Long welded rails at Wantage Rd., 62 1/2 miles from Paddington.

(*b*) *Conditions of lengths.*

The conditions of all long welded lengths so far laid is good, providing smoother riding than with normal jointed track. Figure 1 shows a typical length of welded track.

Difficulty has been experienced in aligning rails correctly during the welding process and the worst of these misaligned welds have had to be cut out and re-welded. These difficulties will be surmounted by improved equipment at depots.

At the ends of the long welded lengths and where resilient pads form part of the track assembly, displacement of these pads has occasionally occurred.

Adjustment switches have generally given no trouble and most are moving freely as the rails at the end of long welded stretches expand and contract. Experiments are in hand to produce a simple and economical design. Figure 2 shows one of the present designs of adjustment switch used.

Isolated cases of buckling have been experienced on long welded lengths, whilst on curved track there has been a tendency in at least one instance for the track to move downhill towards the inside of the curve.

(*c*) *Maintenance.*

In general, whilst the relatively few long welded lengths have required less maintenance than normal jointed track, it is too early yet to reach any definite conclusions as to the extent of the maintenance savings to be expected.

Difficulties have been experienced with certain fastenings on concrete sleepers, mainly with respect to gauge maintenance, but these are being overcome in later designs.

Machine tamping immediately following installation is normally carried out.

This final point concludes the main field experiences gained and practices evolved from the long welded lengths laid in so far, and from the aspect of practical installation and maintenance they have proved invaluable to the men on the job and have afforded to them ample opportunity to become familiar with this type of track.

Field measurements and laboratory tests.

The main object of this paper is to present the work carried out and the various conclusions reached on field measurements and laboratory tests.

Clearly, the elimination of rail joints appears to pose a problem since the joints originally existed, amongst other reasons, in order to absorb the longitudinal expansion which the rail would tend to undergo as a result of temperature change. At first glance, it would appear that if a 60 ft rail can expand

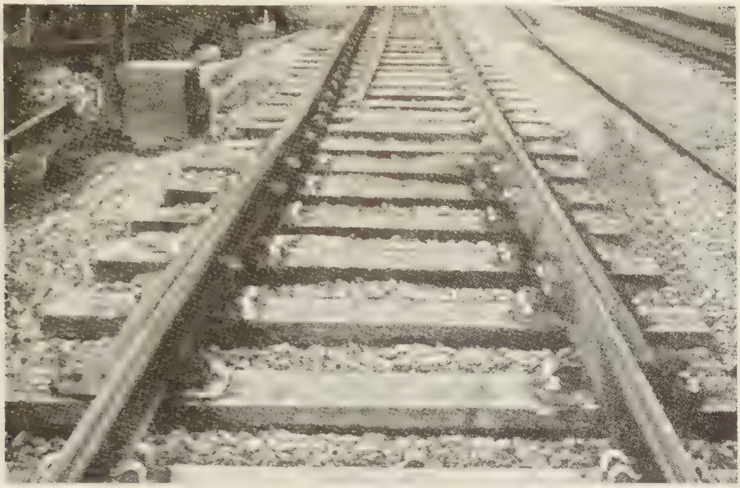


Fig. 2. — Adjustment switch for de-stressing long welded rails at Llanwern.

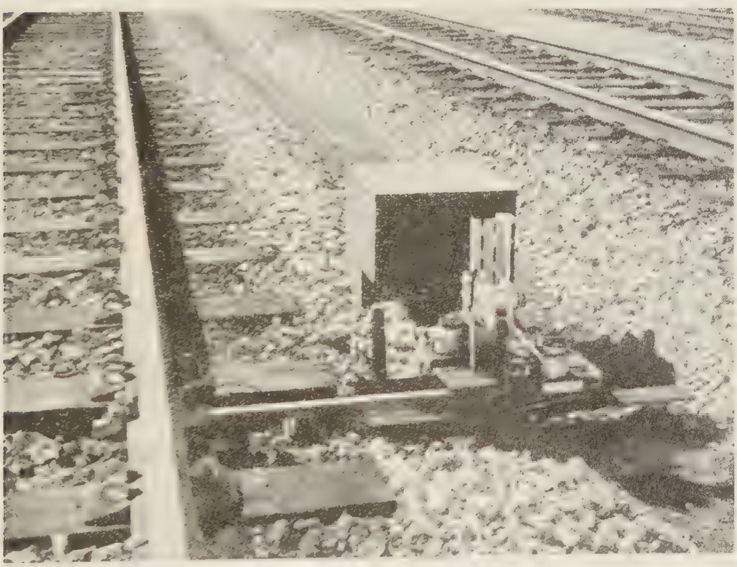


Fig. 3. — A recording point for testing long welded rails at Llanwern.

by an eighth of an inch then a rail half a mile long would expand by 5 1/2 in! This, of course, represents a somewhat naive viewpoint but presents one limit to the problem. The other limit is obtained by assuming that the rail is unable to expand in the slightest by virtue of the longitudinal resistance offered by its fastenings and ballast in which case forces proportional to the temperature rise are acting on the rail. It should be noted that where no expansion is allowed, the force acting on the rail for a given temperature rise is independent of the length of the rail involved so that in theory a length of

jointed track with frozen joints would suffer the same compressive force as a welded length provided that they both became stressed at the same temperature.

A brief recapitulation of the elementary thermal expansion theory leading to the above conclusions might be an advantage at this stage.

If l_1 = Original length of rail.
l_2 = Final length of rail.
t = Temperature rise.
α = Coefficient of linear expansion.

Then $l_2 = l_1 (1 + \alpha t)$ . . . . (1)

If δl = Change of length $= l_2 - l_1$

Then $\delta l = l_2 - l_1 = l_1 (1 + \alpha t) - l_1$

i.e. $\delta l = l_1 \alpha t$ . . . . (2)

If P = Longitudinal force in rail fixed at both ends.
A = Cross Sectional area of rail.
E = Modulus of Elasticity of rail steel.

Then $E = (P/A)/(\delta l/l_1)$

i.e. $E = Pl_1/A\delta l$ . . . . (3)

Then from equation 2

$E = Pl_1/Al_1 \alpha t = P/A \alpha t$

i.e. $P = EA \alpha t$ . . . . (4)

Equations 2 and 4 support the statements that the expansion is proportional to the original length and the force is independent of the original length.

In practice, as will be shown, it is found that the true state of affairs lies between these two limiting cases for long welded rails subjected to temperature rise. From the foregoing, however, the main problem, in so far as it affects laboratory experiments and field measurements, becomes clear, namely to investigate the forces acting on a long welded rail due to elimination of joints and to find the effect of these forces upon the resistance of the track to buckling.

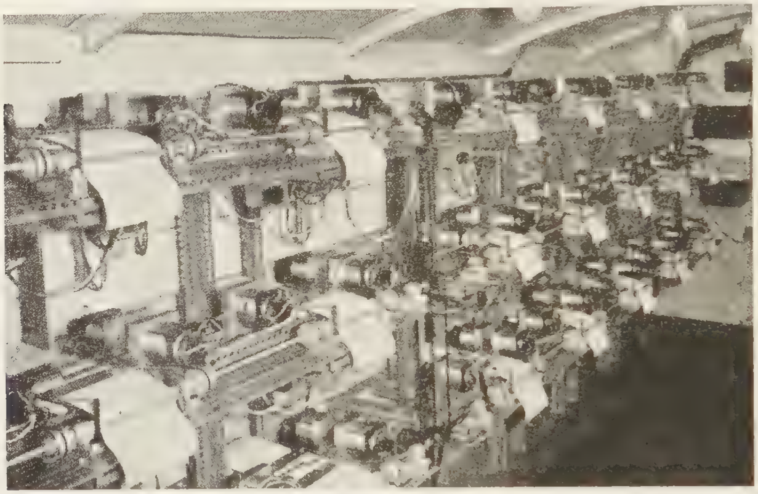


Fig. 4. — Interior view of a special recording van for use at Treforest.

Site measurements.

In order that laboratory experiments designed to simulate field conditions could be devised, it was necessary at the outset to instrument a length of welded rail track and obtain data of movements and temperature changes. Accordingly a length of straight welded track and later a length of curved welded track was chosen in South Wales and extensive instrumentation set up to obtain these necessary data.

In so far as movements were concerned, the first length of half a mile had eighteen recording points ranged along its length,

initially spaced equidistantly. Each recording point or station consisted of a bar fixed rigidly to the rail and projecting horizontally out towards the cess or six foot way. At the end of the bar was affixed a metal cube so arranged as to have a machined surface parallel to each of the three possible directions of movement of the rail, i.e. lateral, longitudinal and vertical.

Fixed to monuments concreted into the cess and six foot way were three magslips each of which, by means of a rack and pinion mechanism, was so arranged as to have its own spring-loaded push rod bearing against one of the three machined surfaces on the metal cube fixed to the rail (fig. 3). By electrical linkage the outputs of each of these magslips was conveyed to a twin repeater magslip located in a recording van (fig. 4). By a reverse mechanical linkage the electrical input to the repeater magslip was converted to a reciprocating mechanical motion which was utilised to propel a pen across a moving roll of paper. Hence by this arrangement the movement of the rail in any of three dimensions at each recording station was automatically and continuously recorded.

Such recordings went on for nearly three years at the two sites chosen although after a short time the spacing of the recording stations was altered so as to concentrate them towards the end of each long welded length under test. Simultaneously, continual recording of rail and air temperature was carried out. For these measurements, some 270 magslips and over 40 miles of cable were used and it says much for government specifications that after nearly three years of continuous usage the magslips (which were ex-government surplus stock in origin) were recovered and after superficial servicing, all were, and in fact still are, in perfect working order.

Results from site measurements.

Whilst the volume of data obtained from this continual recording was prodigious, the main findings from the particular lengths investigated can be briefly summarised as follows :

(*a*) *Movements.*

Apart from any overall movement which may occur due to creep, movement of long rails due to thermal stresses is limited to the end 100 yards or so. This appears to be true irrespective of the overall length of the welded rail.

The value of about 100 yards quoted as moving at the ends of a welded length is slightly variable and it has been established that it depends upon the type of fastening used and the temperature encountered as one might imagine. Whilst not experimentally verified it seems fairly clear that it also depends upon the longitudinal resistance which is dependent upon the type of ballast and sleepers. No relationship between vertical or lateral movements and temperature variation was discovered.

Thus since, as has already been shown, the force in a length of rail which is restrained from moving is independent of the length involved, it follows that there exists no greater stress in the static part of a length half a mile long than in the static part of a length five miles long, to exaggerate the point.

This factor was obviously of immense practical importance since it became immediately clear that only one set of stress conditions needed to be studied and that having satisfied oneself of the ability of the track to withstand these conditions, the limitations as to lengths to be laid were governed only by practical considerations of handling, laying, etc.

(*b*) *Temperatures.*

As established earlier, the compressive force in a longitudinally restrained rail is directly proportional to the temperature rise and the maximum and minimum rail temperature to be encountered is therefore of prime importance. In the location chosen (South Wales), the minimum recorded rail temperature was 8.6 deg F and the maximum was 124 deg F. Slightly lower and slightly higher rail temperatures have been recorded elsewhere by the Research Department of British Railways and current investigations are in hand by the Western Region Labora-

tory to measure rail temperature in other geographical locations on the Western Region. It seems unlikely from site tests that the rail temperature in this country will ever be greater than about 128 deg F. For the purpose of this work, however, the values of 8.6 deg F and 124 deg F actually measured will be taken as operative.

Interesting information as to the variations of temperature diurnally and seasonally was obtained from the recordings. Thus for example daily ranges of from 55 deg F to 70 deg F occurred frequently in the rail between April and September inclusive.

Thus from these site data valuable basic information was obtained concerning the conditions which long welded rails in this country could be expected to have to withstand and upon these data were based experiments to study in detail the resistance of long welded track to buckling.

Laboratory experiments.

It is important to recall two basic facts emerging from the work already described.

1. The major part of a long welded rail length does not move longitudinally as a result of temperature rise.

2. As a consequence, the rail is stressed compressively proportional to the temperature rise.

Based upon these facts an experimental rig was designed and built which would simulate on a full scale, the central major part of a length of long welded rail subjected to a temperature rise. A photograph of the buckling rig is shown in figure 5, whilst a line drawing of this rig appears as figure 6.

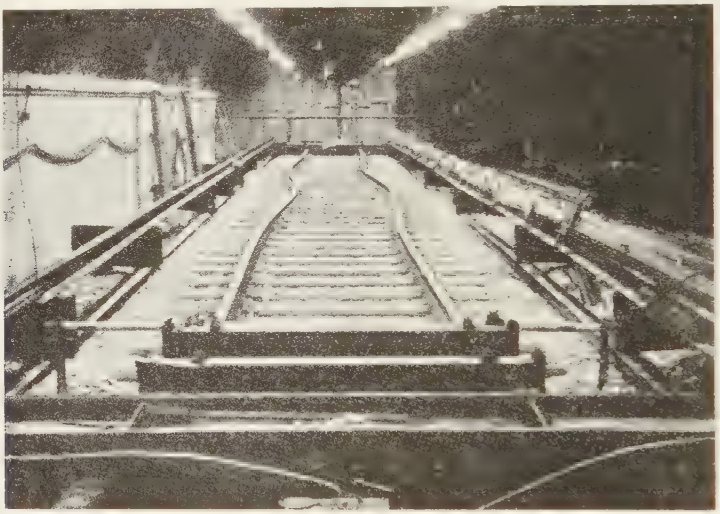


Fig. 5. — View of a length of rail under buckling test.

It consisted basically of a track bed 120 ft long on which could be laid a length of welded track complete in all respects. Each end of the length was encastred and longitudinal movement was prevented by means of massive cross beams and longitudinal ties. It was clear at the outset that introduction of compressive forces in the track could not validly be made by any jacking system.

If true simulation of the field conditions was to be approached it was clearly necessary actually to heat the rails. This was done by ranging along each rail a series of parabolic reflectors fitted with electric fire

elements, and it was found that with this arrangement a compressive force in each rail of about 75 tons could be induced. This high value was achieved by the fact that the rig was located in a disused tunnel and by closing its ends, heat losses to the atmosphere were reduced to a minimum.

During heating, slight expansion of the restraining tie bars was counteracted by the presence of two hydraulic jacks interposed between cross beams and ties. The use of the jacks, however, was strictly limited to curtailment of expansion and not as a medium for actual compression.

With such a test apparatus, the effect of the many variables upon the buckling load of a long welded track could be simply investigated. The details of the actual test procedure are outside the scope of this paper so that it is perhaps sufficient to say that after many full-scale bucklings of various types of track with various conditions of ballasting, sleeper spacing, etc., it was possible to evolve an empirical theory which enabled the ultimate buckling load of a given track to be predicted with a very fair degree of accuracy.

Before considering the final formula which was derived from this work, it is perhaps better to consider what happens when a length of track is caused to deflect laterally by a longitudinal compressive force, i.e. to buckle.

Firstly, it will be understood that if the track were perfectly straight and the points of equal load application central for each rail, then the track would not buckle, however great the longitudinal compressive force. In practice, however, no track exists under these ideal conditions and, therefore, the conditions for buckling are always present, i.e. in practice the rails are always initially misaligned by a certain amount and in the event of the compressive force reaching a sufficiently high figure, buckling could occur.

Consider, therefore, a length of track in the static portion of a long welded length and having an initial misalignment in it before stressing occurs. This misalignment is measured by taking the length l over which

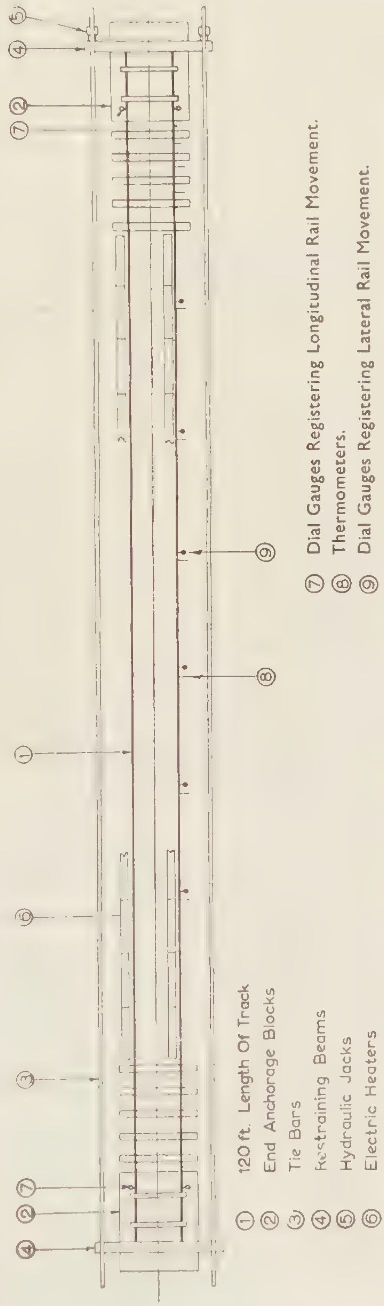


Fig. 6. — A drawing of the test rig used during experiments to investigate the buckling of rails due to temperature rise.

the track is offset from the original longitudinal axis and recording over this length, the maximum offset q. Thus the ratio l/q is sufficient to define a given misalignment. Without very great consideration it will be obvious that the greater the offset q for a given length l, the less will be the buckling load necessary, and vice versa.

After application of the longitudinal compressive force P begins, the factors resisting the further lateral bending of the track are threefold, the first of which is the stiffness of the rails themselves to bending and here again clearly the buckling load is proportional to the elasticity E and moment of inertia I of the rail steel and rail section respectively.

Secondly, assuming that during a lateral movement of the track, the sleepers remain at right angles to the original track alignment (and this assumption is fully justified in practice), it will be fairly obvious that for the rails to bend with respect to their original longitudinal axis, a rotation of the rails relative to the sleepers must occur. Clearly, only one thing resists such a rotational movement and this is the torsional resistance (denoted by a torsional coefficient C) afforded by the fastenings and equally clearly, the buckling load is again proportional to this torsional resistance.

Finally, as a further resistance to lateral movement of the track the ballast itself, from friction and from passive pressure on the sleepers, contributes a share and once again the higher the ballast resistance W the higher the buckling load.

No mention has so far been made of sleeper spacing D but this factor is really implicit in both the resistance afforded by the fastenings and by that afforded by the ballast, since, over a given length of track, the resistance from fastenings and ballast is cumulative and dependent upon the number of sleepers in that length. Here again it is possible to observe quite generally that the greater the number of sleepers (i.e. the smaller the sleeper spacing), the greater the buckling load.

Most of the foregoing deductions are obvious, but it is as well to have them clearly set out at the outset. They may be summarised using the symbols as already defined as follows :

$$P \propto l,\ E,\ I,\ C,\ W,\ l/q,\ 1/D$$

Now, whilst the general relationship between these variables and the buckling load may be logically deduced, the exact relationship is not by any means so clear-cut. The problem may be treated perfectly theoretically but it was felt that a better method was to establish from experiment the interaction of these various factors and from this evolve a theoretical expression to fit the measured facts. This was the procedure adopted and the final formula established, relating ultimate buckling load with the variables concerned, was as follows :

$$P_b = \pi^2 \ EI_s/l^2 + (\pi^2 C/16D) \sqrt{(\pi l/q)} + W_d \ l^2/\pi^2 \ Dq$$

where :

Pb = ultimate buckling load;
E = Modulus of Elasticity of rail steel;
I_s = Moment of Inertia of two rails;
l = Length over which buckling is likely to occur and which has for simplicity been taken as 20 ft in all cases;
q = Maximum misalignment occurring in length;
C = Torsional Coefficient of Fastenings;
D = Sleeper Spacing;
W_d = Maximum Lateral Ballast Resistance/Sleeper.

From the above it will be noted that a value for l of 20 ft is suggested as being convenient to use in all cases. It must be borne in mind that this is an attempt to simplify the resultant formula so as to make it convenient for general use. In actual fact, for any given combination of C, D, W_d and q there exists only one value of l which will yield a minimum value of P_b and for various combinations of these variables, so a range of l values would emerge. For practical use, however, a good average value of l has been chosen and as will be shown later a correspondingly practical value of q to use in this work is 1/4 inch.

In the above formula the term :

$$\pi \ EI_s/l^2$$

refers to the contribution from the stiffness of the rail section, the term :

$$(\pi^2 C/16D) \sqrt{(\pi l/q)}$$

refers to the contribution from the torsional resistance of the fastenings, and the expression :

$$W_d \, l^2/\pi^2 \, D_q$$

refers to the part played by the ballast resistance.

It will be seen that the relationship between each variable and the buckling load is as would be anticipated from a common sense consideration of the system.

The various factors appearing in this formula can be grouped into three categories :

1. Those which are measurable properties of the rail and do not require experimental verification, i.e. E and I_g.

2. Those which are simply linear dimensions and are usually a matter of common occurrence in practice, i.e. l, q, and D.

3. Those which are experimentally obtained and the values for which must be given, i.e. C and W_d.

Of those variables under category 2 above, l and q, it will be recalled, are a measure of the misalignment occurring in a track before it becomes stressed and they are therefore a question of maintenance. In order to determine the order of l and q found in practice an investigation in the field was carried out to measure, amongst other things, these two dimensions. It was found, after inspecting some thirty widely spaced sites, that the maximum misalignment was 0.3 in on a 20 ft length and that therefore, in estimating the factor of safety of track, such figures should be taken as being operative.

In category 3 above it is a question of establishing experimentally the values of the variables.

Two basic methods of establishing the torsional resistance of a fastening exist. One is a direct method and is termed the Torsional Resistance Test and the second is an indirect method and is termed the Lateral Moment of Resistance Test.

Appendices 1 and 2 respectively will describe these two tests, together with the method of derivation of the Fastening Torsional Coefficient from each.

The results from both tests in so far as cross sleepered track is concerned should agree although the method of carrying out the Lateral Moment of Resistance Test should provide inherently more accurate results due to the larger number of fastenings under test.

The lateral ballast resistance is the last experimentally derived quantity needed to predict the buckling load of a given type of track. Appendix 3 will describe the test and list values of this resistance for different types of sleepers and ballasting conditions.

The main points of note from this test are that the ballast resistance is dependent upon :

(a) The dimensions of the sleeper.
(b) The weight of the sleeper.
(c) The nature of the sleeper.
(d) The size grading of the ballast.
(e) The amount of ballast.
(f) The nature and conditions of the ballast.
(g) The state of compaction of the ballast.

The total lateral ballast resistance can be subdivided into three components :

(a) Friction beneath the sleepers due to the weight of the track.
(b) Friction on the sides of the sleepers due to boxing.
(c) Passive pressure of the ballast shoulder at the end of the sleepers.

Factor of safety of long welded track against buckling.

It may be convenient at this stage to recapitulate the main points so far established.

1. *The problem.*

To investigate the stability of long welded rail track and to enumerate the steps necessary to maintain stability.

2. *The steps taken to solve the problem.*

The measurements taken and the tests devised and carried out have been described. The tests so far considered are :

(a) The Buckling Test.

(*b*) The Torsional Resistance Test.
(*c*) The Lateral Moment of Resistance Test.
(*d*) The Lateral Ballast Resistance Test.

3. *The results so far.*

A practical formula has been evolved relating ultimate buckling load with a given type of track and given maintenance standards.

Appendix 4* demonstrates the practicability of the formula established by comparing the experimental and theoretical results obtained from different types of track with various maintenance conditions. The final column in this table shows the percentage difference between experimental and theoretical buckling loads.

Interest has been expressed concerning the relative importance of the contribution from each of the main components (namely the rails, the fastenings and the ballast) to the total buckling resistance for a given track. It is not possible to lay down definite percentage contributions for each of these components since clearly, and as will be shown later, the absolute value obtained from each component is dependent very largely upon the conditions of maintenance obtaining. As an example, if there were no ballast resistance acting for some reason or other, the contribution from the rails and fastenings could be of the order of 30 and 70 % respectively whilst, on the other hand, if the full ballast resistance were acting, the equivalent percentage contribution from rails and fastenings respectively could fall to 10 and 20 %. There are for practical purposes 5 variables involved in the expression for the buckling resistance of a length of track each of which may have a number of values. It is clearly not a practicable proposition therefore to consider all these combinations in order to determine the percentage contribution range of each component of the buckling resistance. It is difficult even to estimate an average set of values but using the criteria set out later the percentage contribution from rails, fastenings and ballast becomes very approximately 30 %, 10 % and 60 % respectively. It cannot, however, be emphasised too strongly that these figures apply to one set of conditions only and the choice of another set of conditions could completely change the picture.

Both from the commonsense approach and from the buckling formula established, the controllable factors contributing to a high resistance to buckling can be summarised :

1. A high torsional resistance from the fastenings.
2. A small sleeper spacing.
3. A high ballast resistance
4. A high l/q ratio, i.e. small misalignment.

Factors 1 and 2 are matters of choice whilst 3 and 4 are matters of maintenance.

It is now largely a question of attempting to decide what is a realistic factor of safety which a track must possess against buckling so that the necessary steps, if any, can be decided upon to achieve this factor of safety.

The maximum buckling force which can act on the welded track is fairly clear and is purely dependent upon the maximum temperature rise likely to be experienced in this country (see eqn. 4). It has already been shown that the maximum temperature range is from 8.6 deg F to 124 deg F but this overall range is nearly halved by the practice of laying in or destressing long welded rails between the temperatures of 55 deg F and 75 deg F. The maximum temperature rise likely to be encountered as a result of this, therefore, is from the minimum destressing temperature of 55 deg F to 124 deg F, i.e. about 70 deg F. By substitution of the appropriate values for F.B. track in eqn. 4, the Load/deg F rise in temperature can be calculated and is 1.8 tons for two rails. The maximum load acting on the track therefore for a 70 deg F rise is 126 tons.

Reference to Appendix 4 which gives examples of buckling loads achieved by various types of track under given ballast conditions shows that loads much less than this were measured. However, the conditions chosen for this table were arbitrary or experimentally convenient, and whilst the contribution from the rails themselves and

* Appendices 1 to 3 and Appendix 4 are reproduced at the end of this article.

from the fastening were realistic, the standards of maintenance chosen were almost certainly not typical of those existing in practice.

Accordingly, the investigation previously referred to, in which values of misalignments commonly occurring in practice were measured on site, was extended to cover voids, hanging sleepers and tensioning of fastenings.

To summarise the findings from this work :

(i) The maximum misalignment measured was about 1/4 in in 20 ft.

(ii) Approximately 65 % of all sleepers examined had voids beneath them.

(iii) A succession of hanging sleepers (up to five) occurred quite frequently with an isolated case of eleven consecutive hanging sleepers.

(iv) Approximately 50 % of the type of fastening examined were undertensioned and some 15 % overtensioned.

(v) There was an increase in the number of undertensioned fastenings with age.

The translation of these measured facts into their effect upon the buckling resistance is not necessarily straightforward. Thus, for example, the fact that eleven consecutive sleepers could be hanging means that the whole of an initially misaligned length of 20 ft could be in this condition. Even, however, assuming this to be so, is it correct to translate the effect of hanging sleepers into the non-contribution of the ballast resistance beneath them or is it more justifiable to assume a proportion of this still acts ? Does the boxing contribution become less due to the sleeper moving up and down under load ? Do the 50 % undertensioned fastenings mean that the operative fastening coefficient as measured on a new fastening becomes halved or does it become only slightly reduced ?

Is it justifiable in any case to assume these presumably worst conditions acting simultaneously on a given length of track ?

These problems and their resolution proved to be one of the more difficult parts of the whole project since the answers could not always be factually justified. Tentative experiments on secondhand track indicated for example that the fastening coefficient of a given fastening could fall to 25 % of its « as new » value, but whilst it might be conceivably justifiable to assume that the coefficient of all fastenings which rely for their functioning on the same principle as this particular type might also fall by this amount, it was by no means justifiable to assume that types with quite different methods of functioning would behave in the same manner with respect to time.

Eventually it was decided, as a test case, to take the worst maintenance conditions which could be remotely justified, the torsionally weakest fastening tested, assume all to be acting simultaneously on one piece of track and evaluate the buckling resistance.

The conditions chosen were :

(*a*) $l = 20$ ft.

(*b*) $q = 1/4$ in.

(*c*) Compacted ballast resistance from shoulders only.

(*d*) Torsional coefficient of weakest fastening tested, reduced to one-quarter of its « as new » value.

With these conditions and the appropriate values inserted in the buckling formula the load evaluated was 122.5 tons.

The significance of this result is that track of this type and with the assumed standards of maintenance would not have quite withstood the maximum temperature rise of 70 deg F. The fact that welded track in the field has successfully withstood such a temperature rise does not necessarily invalidate the conclusion or the assumptions made in arriving at it.

The calculation and its results are, however, not of any great practical importance except to indicate that buckling could occur under certain circumstances. A precisely similar calculation except for the substitution of full ballast resistance shows that the factor of safety rises to 2.6. These figures serve to demonstrate the order of the factors of safety with which we are dealing and it is of interest in this connection to note the maximum factor of safety which it is possible to achieve without actually securing the

track physically to the ground. This maximum is achieved when the track is so stiffened laterally that its buckling resistance is equal in both the lateral and the vertical planes. Clearly this condition represents the ultimate and under this condition the buckling load is of the order of 511 tons. The factor of safety then is 511/126, i.e. 4, and no further increase can be obtained.

It should be pointed out at this stage that the preceding remarks are all concerned with flat bottom track. The substitution of bull head would in no way affect the conclusions made or inferences drawn, but would merely affect actual physical values. It is perhaps worth comparing at this point the buckling loads of bull head and flat bottom tracks. There are two main differences between the two from the lateral stability aspect, one being the moment of inertia of the rail section which is less for B.H. than for F.B. rails and the other being the type of fastenings in use with both types. In this respect, of course, the wooden or steel key used with B.H. track is basically different from most types of fastenings used with F.B. track, being very much more resistant, by virtue of its wedging action against the *side* of the rail, to lateral bending of the rail. The combination of these two factors, i.e. reduction in the lateral stiffness of the rail section and the increased torsional stiffness of the fastenings, tends to result, if anything, in an overall increase in lateral stiffness for B.H. tracks. This, however, is offset by reduction in the critical buckling length of such track, such that in the final result buckling resistance of B.H. track, all other conditions being equal, is slightly less than F.B. track.

Conclusions on the stability of long welded rails.

It has been shown that under certain critical conditions, long welded track can buckle and with this conclusion it can be stated that the first part of the original problem has been completed, namely to investigate the forces acting on a long welded rail and to find the effects of these forces upon the resistance of the track to buckling.

The second part of the original problem, namely to enumerate the steps to be taken to maintain the stability of welded track, can now be approached.

A list of the steps which will increase the buckling resistance has already been set down and it is now convenient to consider the practical implications of attempting to conform to these measures.

1. *Torsional resistance of fastenings.*

If it were possible to lay down the sleeper spacing, to define with certainty the minimum standard of ballast and alignment maintenance which a long welded length will possess (and the difficulties of doing this have already been discussed) and were it then possible to lay down the minimum factor of safety against the maximum temperature rise which it is desired that this track should have, then it would be possible to lay down with corresponding certainty, the minimum torsional coefficient that the fastenings used should possess.

Thus, as an example, taking the conditions outlined above, i.e. items (*a*), (*b*) and (*c*), assume the required sleeper spacing to be 31 in, with wooden sleepers, and lay down a minimum factor of safety of 2, i.e. to withstand 252 tons, then the necessary torsional coefficient value can be readily evaluated from the buckling formula and this calculation will yield a value of 128.

This value is not intended to be of any practical significance but to be purely an example and any number of so-called « necessary torsional coefficient values » can be obtained by similar calculations depending upon the conditions assumed or laid down.

A tentative set of conditions used is as follows :

1. $l = 20$ ft.

2. $q = 1/4$ in.

3. Compacted ballast resistance, wooden sleepers, full shoulder resistance acting only.

4. Sleeper spacing 31 in.

5. Torsional coefficient can fall to one-quarter of its « as new » value.

6. Factor of Safety—unity.

On this basis the minimum torsional coefficient for wooden sleepered fastenings becomes 51.

It is of interest to note that only one wooden sleepered fastening tested had a coefficient greater than 51.

As a further example of the effect of assuming different conditions, if an arbitrary 8 % of the boxing were also assumed to be contributing to the ballast resistance, this value of 51 would fall to 40 and this drop would then enable all the wooden sleepered fastenings tested except four to be pronounced as acceptable.

Sufficient has been written to demonstrate the sensitivity of this torsional coefficient but equally, little doubt should remain that a high value is desirable, at least in a wooden sleepered fastening. It might be appropriate at this stage to point out that in so far as concrete sleepered fastenings are concerned, the need for a high torsional coefficient is not so great due to the greater ballast resistance with these heavier sleepers.

Some 47 different fastenings have so far been tested (including variations on the same basic fastening), and very broadly these fastenings tested can be divided into the following four main types dependent upon the manner in which they apply a load to the rail :

1. Those in which the load on the rail is derived from a frictional grip or « nailing » effect.

2. Those in which load application is via a nut and bolt or screw thread.

3. Those in which the load is predetermined in the design stage and which cannot be varied in assembly.

4. Those which apply their load by a wedging action against the rail either vertically or laterally.

2. *Sleeper spacing.*

Since sleeper spacing is a clear matter of choice and since it directly affects the buckling resistance, it is only a question once again of attempting to enumerate precisely the same sort of maintenance standards, etc., as it was necessary to enumerate at the beginning of the preceding observations on torsional resistance.

With any given sleeper spacing and all the other variables laid down, a given buckling resistance is obtained. By reducing the number of sleepers and increasing the torsional resistance of the fastening, or vice versa, an equal buckling resistance can be obtained. The whole question of desirable sleeper spacing, therefore, becomes one of comparative economics between saving by reduction of the number of sleepers used as compared with the extra expense of torsionally stronger fastenings. There are, of course, other aspects as to the desirable number of sleepers to be employed per unit length which may outweigh the above simple comparison.

An alternative choice, however, is available. A study of Appendix 3 reveals that the ballast resistance afforded by concrete sleepers is higher than that afforded by wooden sleepers. Therefore, for a given buckling resistance, less concrete than wooden sleepers are needed.

Appendix 5 lists examples of the variation in buckling loads obtained by various combinations of sleepers and fastenings.

To summarise, therefore, the position re sleeper spacing and using the figures in Appendix 5 as examples, if, say, 325 tons was acceptable as a buckling resistance and the conditions laid down for the calculation of the figures in Appendix 5 happened to be also acceptable then this value could be achieved by using 27 wooden sleepers/60 ft with fastening type 10 or 26/60 ft with fastening type 4 or 24/60 ft with fastening type 3, etc.

3. *Ballast resistance.*

It is obviously true to say that a high standard of maintenance will produce a high ballast resistance, and it is probably in this respect that the greatest increase in buckling resistance can be obtained. A study of Appendix 3 will show that the values of resistance can vary by over 100 % depending upon the degree of compaction and amount of the ballast. If it were possible to guarantee for example, at all times, the

compacted fully ballasted conditions with no hanging sleepers, then the contribution by the fastenings and even the rails could be neglected, since they would form a small proportion of the total. Unfortunately this cannot be guaranteed and all that it is possible to say is that considerable dividends can be gained by good ballast maintenance and equally, and perhaps of more importance, considerable losses can be incurred by bad maintenance.

Little further comment can be made generally on ballast resistance except perhaps to point out with reference to Appendix 3 that little extra increase, if any, in resistance is gained by enlarging a compacted ballast shoulder above 12 in and even were this so, in this country the cess width would preclude a larger shoulder even if the cost justified it.

Resistance of fastenings to longitudinal rail movement.

In order to reduce the length of rail moving or « breathing » at the end of a long welded length due to temperature stresses, it is clearly desirable to have a high creep resistance for a fastening. It must, of course, be pointed out, however, that there is little point in having a creep resistance greatly in excess of the longitudinal ballast resistance since movement of the rail relative to the ground will then merely occur by movement of the sleepers through the ballast.

Ideally, for economic disposition of available forces, the creep resistance of the fastening should equal the longitudinal ballast resistance. In practice, however, this would be difficult to achieve for a variety of reasons not the least of which is inability to be able to guarantee a given ballast resistance.

The variation also of the creep resistance with time is another factor which would preclude the realisation of this ideal.

Experiments to investigate the nature of creep resistance were carried out at the same time as the work on the stability of long welded rails previously discussed.

Appendix 6 describes the two tests used for this investigation. The Static Creep Resistance Test gives a measure of the « as new » resistance offered by the fastening to creep whilst the Dynamic Creep Resistance Test gives a measure of the variation in creep resistance which occurs after dynamic loadings.

Longitudinal ballast resistance tests were also carried out in connection with this work, the apparatus used being essentially the same as that used for lateral ballast resistance and which is described in Appendix 3.

Future work.

One aspect not so far investigated is the question of dynamic effects. With the exception of the Dynamic Creep Resistance Tests no experiments have been carried out on the effect of live loading . This represents clearly a gap in the overall picture since railway track is essentially « alive » for a large part of its life.

Reference has been made in various parts of this article to these dynamic effects and for the purpose of investigating their effect upon track stability, both lateral and longitudinal, and upon fastening and resilient pad design, it is not really essential to know the cause of these dynamic effects. What it is clearly essential to know is just what these effects are upon the components which make up the track. This aspect must form the primary object of any future work. It may be necessary as a secondary consideration to investigate the causes amongst which are the more obvious ones of precession waves, hammer blow, side thrust, etc.

Even prior to the carrying out of experiments, one may speculate as to the nature of the dynamic effects which track and its various components may suffer. It seems fairly certain both from preliminary work in the Western Region Laboratory and from work carried out by the S.N.C.F. in France that superimposed on the heavy, high amplitude, relatively low frequency loadings arising from the passage of rolling stock there are high frequency, small amplitude

vibrations, also occurring, and it may well be that the latter have the most marked effect especially upon fastening and resilient pad behaviour.

Clearly a fastening and resilient pad combination operating under these dynamic effects must be capable of maintaining an effective creep and torsional resistance and simultaneously must be able to absorb the high frequency vibrations and prevent their undue transmission to the sleeper.

The order of the accelerations measured by the S.N.C.F. is high, i.e. exceeding 100 *g* and operating at about 800 cycles/second. Very preliminary work by the Western Region Laboratory in so far as frequency is concerned indicates values even higher than 800 c/s, although no acceleration values are yet available.

Accepting, however, the French figures for accelerations, the forces arising as a result of these accelerations acting on sleepers are considerable, i.e. of the order of 27 tons as far as concrete sleepers are concerned and the effect of such forces acting in a vibratory manner can be imagined. Final figures for British conditions may not give the same values but clearly the whole matter is of great importance. The effect of the frequency of vibration as distinct from the accelerations is also important. As mentioned earlier, one of the functions of a fastening is to maintain under dynamic loadings, its creep and torsional resistance features. With the presence of a high frequency vibration in the rail, the ability of the fastening to respond to these rapid rail movements is important and unless the natural frequency of vibration of the fastening is higher than that of the rail it will be unable to do this. Unfortunately the provision of a high natural frequency in a fastening directly opposes another desirable feature of a fastening namely small variations in applied load for large deflections, and it seems likely that a compromise will need to be reached in these two respects.

Acknowledgment.

The author is indebted to M. G. R. Smith, Esq., M.B.E., B.Sc., M.I.C.E., Chief Civil Engineer, British Railways, Western Region for permission to publish this article and to those staff of the Civil Engineering Laboratory of that Region who devised and constructed the apparatus and carried out the work described in particular to Mr. J. Tuora who was largely responsible for the mathematical side of this work.

APPENDIX 1

Torsion test machine.

The torsion test machine consists of a hydraulically operated ram mounted on a frame on which a sleeper with a short length of rail attached to it can be clamped (figs. 7 and 8).

A hydraulic mechanism allows the speed of the ram to be altered through an infinitely variable range. This is achieved by having two identical hydraulic pumps connected to an electric motor through identical reduction gears but with the interposition on one of the pump drives of an infinitely variable mechanical gear, with a range from 1/3 to 3 times the mean speed. One pump acts as a motor and the difference between the output of the pump and input of the motor is fed to the ram. It is thus possible to govern the speed of the ram accurately notwithstanding any resistance it might meet.

The sleeper rail assembly is placed on the frame so that the horizontal plane through the centroid of the rail coincides with the axis of the ram, at a distance of 12 in from the centroid of the baseplate. With the sleeper clamped firmly in this position a load is applied through a proving ring to measure the force applied.

Measurements are taken during testing of the movements of the rail and baseplate relative to the sleeper so that the force

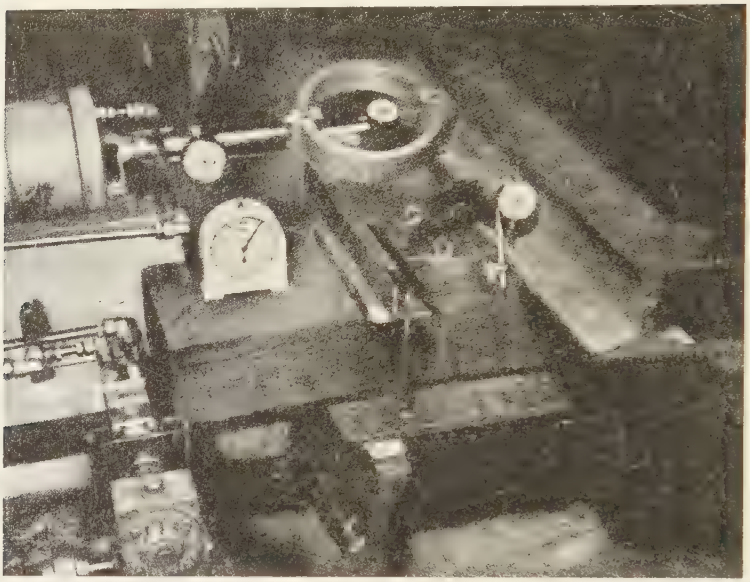


Fig. 7. — Photograph of the torsion test machine.

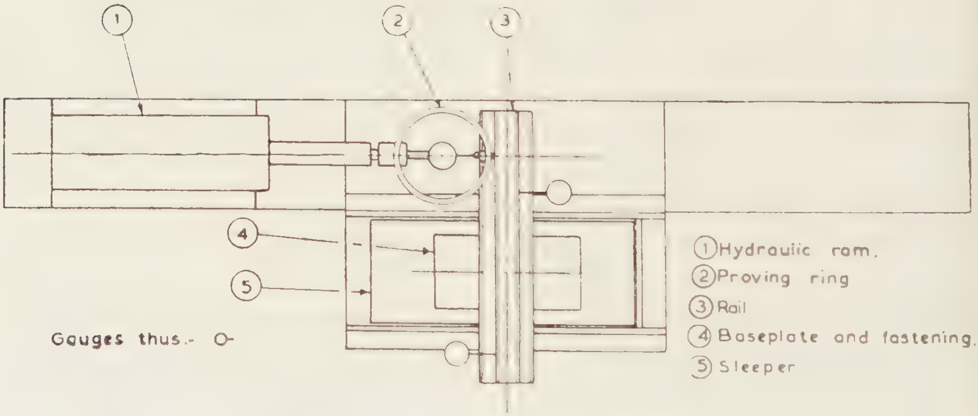


Fig. 8. — The layout of the apparatus.

applied can be related to the movements produced.

Derivation of torsional coefficient "C" from torsional resistance test.

From the results obtained during the torsional resistance test a graph is plotted of the twist of the rail in radians, relative to the sleeper, against the torque applied.

After examining the graphs of a number of different types of fastenings a general assumption has been made that the curves can be expressed by :

$$T = C\sqrt{\alpha};$$

where T = torque applied;

α = angle of twist of the rail relative to the sleeper.

C = A fastening coefficient characteristic for each type of fastening.

This formula has been used as a basis for the derivation of the coefficient C. Over a length of 20 ft in which a misalignment of 1/4 in exists, the angle of twist of the rail relative to the sleepers varies between zero and 0.0035 radians. It follows, therefore, that the torsional resistance of each fastening along such a length also varies and it is necessary to consider this variation in order to establish the appropriate value of the fastening coefficient « C ».

From the torsional test, the relationship between T and α is given by $T = C\sqrt{\alpha}$ and by a process of integration the fastening coefficient is obtained thus :

The area dA of an elemental strip of width $d\alpha$ under the curve :

$T = C\sqrt{\alpha}$ is given by

$$dA = T d\alpha ;$$
$$= C\sqrt{\alpha}\ d\alpha.$$

Therefore total area :

$$A = \int^{\alpha}_{0} C\sqrt{(\alpha)} d\alpha = (2/3) C\alpha^{3/2};$$

i.e. $C = (3/2)\ (A/\alpha^{3/2})$.

APPENDIX 2

Lateral moment of resistance.

The general arrangement of the test rig is shown in figures 9 and 10. A 30 ft length of track is supported at either end on virtually frictionless rollers. Central lateral loads are applied by a hydraulic jack acting against a beam which also provides the reaction for the end supports of the track.

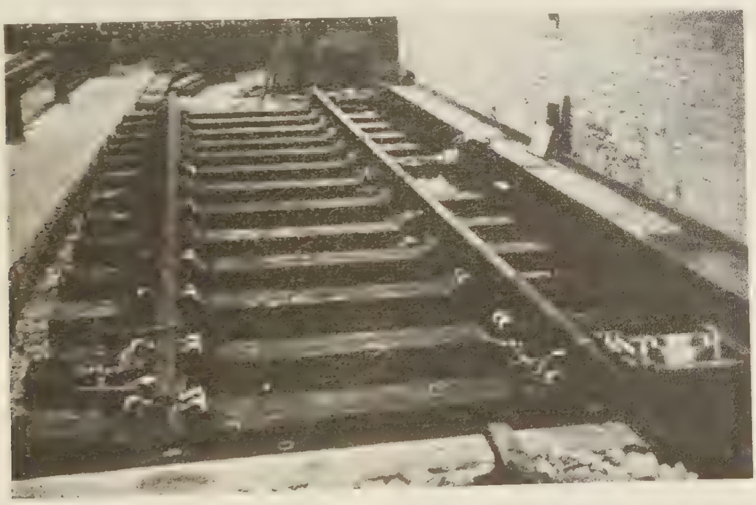


Fig. 9. — View of the test rig.

The load applied and reactions are measured by proving rings and the corresponding deflection of the track obtained from dial gauges placed on the ground at intervals of 5 ft and bearing on the track.

Readings of load and deflection are taken at frequent intervals and curves plotted for each test. The behaviour of the track when the load is released is also noted.

A minimum of three tests for any given set of conditions is performed and the average of the results taken.

Derivation of torsional coefficient " C " from lateral moment of resistance test.

It can be shown that for a track of length l simply supported laterally and with a central lateral load, the bending moment at any point is given by :

$$M_x = E(I_{eq})\,(d^2y/dx^2) = R_R\,(l/2 - x) \quad . \quad (5)$$

where :

I_{eq} = Equivalent Lateral Moment of Inertia of track acting as a beam.

R_R = Reaction at one simply supported end.

E = Modulus of Elasticity of rail steel.

The presence, however, of torsional resistance from the fastenings at each sleeper can be taken into account by considering small moments applied along the track at the appropriate position. The values of these moments are not equal but depend upon the angle of twist at each point. As these angles are small the approximation :

$\alpha = \tan\alpha = (dy/dx)$ is justified.

The misaligned shape of a length of track subjected to bending as described can be represented by the expression :

$$y = q\cos(\pi x/l) \quad . \; . \; . \; . \; . \; . \quad (6)$$

where q = maximum central deflection.

From the torsional resistance test it was shown that the relationship between Torque T and angle of twist α can be expressed by :

$$T = C\sqrt{\alpha} \quad . \; . \; . \; . \; . \; . \quad (7)$$

Now from eqn. 6

$$y = q\cos(\pi x/l)$$

Therefore :

$$dy/dx = (\pi q/l)\sin(\pi x/l)$$

and since

$$\alpha = \tan\alpha = dy/dx$$

then $T = C\sqrt{\alpha}$ can be written

$$T = C\sqrt{[(\pi q/l)\sin(\pi x/l)]} \quad . \; . \quad (8)$$

This equation represents the torque applying at points along the length of the track under test and it is now necessary to establish the average value of the torque applying along the length of the deflected track. This is carried out by plotting the curve of T against l using equation 8 and integrating, etc., as in the torsional resistance test. The average torque can be shown to be given by :

$$T_{av} = 3/4c\sqrt{(\pi q/l)} \quad . \; . \; . \; . \quad (9)$$

Now reverting to the expression for the bending moment in the track under test,

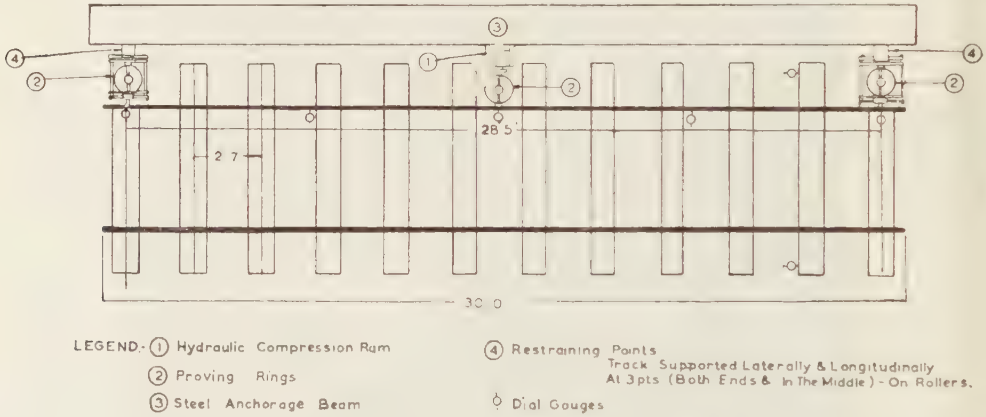


Fig. 10. — General arrangement of the test rig.

this can be rewritten :

$$M_x = R_R(l/2 - x) - (2\,T_{av}/D)(l/2 - x)$$
$$= EI_s(d^2y/dx^2) \quad . \; . \; . \; . \; . \; . \; . \quad (10)$$

where D = Sleeper Spacing.

I_s = Moment of Inertia of two rails.

The solution of this equation for y_{max} results in the expression :

$$y_{max} = q$$
$$= (l^3/24\,EI_s)\,R_R - (3/2)\,(C/D)\sqrt{(\pi q/l)}].$$

All the terms in this expression are obtainable from the Moment of Resistance test except C which can therefore be established.

Additionally, it can be shown by subtracting eqn. 10 from eqn. 5 that :

$$I_{eq} = I_s(Cl^2/16D\,E)\sqrt{(\pi l/q)}$$

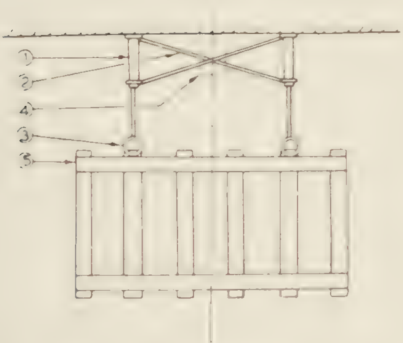
which clearly demonstrates as a sideline issue that the equivalent moment of inertia of track acting as a beam is not constant but is dependent upon the fastenings used, the sleeper spacing and the amount of deflection given to it.

APPENDIX 3

Ballast resistance.

The general arrangement of the test rigs used for ballast resistance tests is shown in figures 11 and 12. A dummy length of track is prepared consisting, in the case of lateral resistance tests, of six sleepers at normal spacing rigidly connected by steel

Fig. 11. — Equipment set up for ballast resistance tests.



① Hydraulic rams attached direct to tunnel wall.
② Tie bars connecting both rams together
③ Proving rings, (5 tons)
④ Pump with ram controls
⑤ Sleepers with 2No steel channels with compensating weight added, or 109 FB rail

Fig. 12. — Layout of the test rig.

channels, compensating weight being added to make up the equivalent weight of the type of track under investigation. In the case of longitudinal tests four sleepers are similarly rigidly connected.

Loads are applied to the track through two hydraulic rams, the movements of which are synchronised at the rate of travel required. The loads applied are measured by proving rings and the corresponding movement of the track is obtained from dial gauges placed on the ground and bearing on the track. Readings are taken at frequent intervals and load movement curves plotted for each test.

A minimum of three tests for any given set of conditions are carried out and the results averaged. Various degrees of ballasting with differing states of compaction are used on each sleeper tested.

	Part of ballasting and type of sleeper Sleeper Spacing 2 ft 7½ in	Under Sleeper					Boxing			
		Tons per ft run	Tons per sleeper	% of total with varying shoulder			Tons per ft run	Tons per sleeper	% of to[tal with] varying	
				6 in	9 in	12 in			6 in	9 i[n]
Lateral	1½ in uncompacted ballast. Timber sleeper	0·039	0·101	47·5	41	37	0·039	0·101	47·5	41
	1½ in compacted ballast. Timber sleeper	0·039	0·101	29	28·7	28	0·066	0·17	49·2	48
	3 in uncompacted ballast. Timber sleeper	0·04	0·103		46		0·035	0·09		40
	3 in compacted ballast. Timber sleeper	0·05	0·128		29		0·113	0·39		65
	1½ in compacted ballast 10 in × 6in timber sleeper	0·062	0·161		16·9	15·9	0·216	0·557		58
	1½ in compacted ballast. Concrete sleeper	0·104	0·268		52·8	42·5	0·072	0·187		38
	1½ in uncompacted ballast. Concrete sleeper	0·083	0·214	63	57·7	48·9	0·043	0·111	32·6	29
	3 in uncompacted ballast. Concrete sleeper	0·071	0·183		56	53	0·05	0·129		40
	3 in compacted ballast. Concrete sleeper	0·102	0·264		31	30	0·178	0·456		5[illegible]
	3 in uncompacted ballast (no trench). French concrete pot sleepers	0·061	0·156		21·8					
	3 in uncompacted ballast (trench in middle). French concrete pot sleepers	0·061	0·156		29·2					

contribution of each component to the total resistance.

shoulder		9 in shoulder			12in shoulder			Total					
								Full mainten. 6 in shoulder		Full mainten. 9 in shoulder		Full mainten. 12 in shoulder	
Tons per sleeper	% of total	Tons per ft run	Tons per sleeper	% of total	Tons per ft run	Tons per sleeper	% of total	Tons per ft run	Tons per sleeper	Tons per ft run	Tons per sleeper	Tons per ft run	Tons per sleeper
0·01	4·87	0·017	0·044	17·9	0·027	0·069	25·7	0·082	0·212	0·095	0·246	0·105	0·271
0·074	21·4	0·031	0·08	22·8	0·034	0·088	24·5	0·134	0·345	0·136	0·352	0·139	0·359
		0·010	0·028	12·8						0·087	0·224		
		0·012	0·03	6·8						0·172	0·444		
		0·093	0·24	25·2	0·121	0·29	28·8			0·37	0·95	0·39	1·01
		0·02	0·051	8·4	0·069	0·176	27.8			0·196	0·506	0·245	0·631
0·015	45·6	0·018	0·046	12·5	0·044	0·113	25·9	0·132	0·341	0·144	0·372	0·17	0·439
		0·005	0·013	4	0·013	10				0·126	0·324	0·135	0·348
		0·05	0·13	15	0·062	0·165	18			0·33	0·85	0·342	0·88
										0·276	0·715		
										0·209	0·535		

COMPARISON BETWEEN THEORETICAL AND

Experiment No.	Track details				Ballast conditions	
	Torsional coefficient of fastening	Type of fastening	Length of misalignment	Misalignment	Nature of ballasting and grading	I l re
	C $\left(\frac{\text{ton in}}{\text{rad}^{1/2}}\right)$		l (ft)	q (in)		W d (
1 check	45**	4/4	29	6/16	1·5in uncompacted ballast under sleepers only	
	46·5*		29	6/16		
2 check	46·5*	4	23·25	4/16	1·5in uncompacted ballast under sleepers only	
	45**		23·25	4/16		
3 check	39*	15	26·58	7/16	1·5in ballast under sleepers	
	55**		26·58	7/16		
14	32·6*	10/3	33·5	8/16	Sleepers on rollers	
	38**		33·5	8/16		
19	32·6*	10/3	33	4/5	1·5in uncompacted ballast under sleepers only	
	38**		33	4/5		

:ING TEST RESULTS. — **Timber sleepers at 31 in spacing.**

Dynamic buckling load								Difference between experiments and theoretical buckling loads (%)
‹. dynamic obtained from experiments		Max. dynamic obtained from theoretical calculations						
mp. se	Corres. max. dynamic load	Carried by rails	Carried by fastening	Carried by ballast	Total	Corres. temp. rise		
F	P (tons)	$\pi^2 EIs/l^2$ tons (%)	$\frac{\pi^2 C}{16\,D}\sqrt{\frac{\pi l}{q}}$ tons (%)	Wd. $l^2/q\ \pi^2$ tons (%)	P tons (%)	°F		
..5	171.19	20.5	48.39	106.5	175.39	97.9		— 2.4
		11.7	27.65	60.65	100			
..5	171.19	20.5	50	106.5	177	98.5		— 3
		11.6	28.25	60.15	100			
5	190.5	32.1	54.8	107.4	194.3	108.7		— 2
		16.5	28.25	55.25	100			
5	190.5	32.1	53.03	107.4	192.53	107.5		— 1
		16.7	27.5	55.8	100			
4.7	151.8	24.48	37.3	76.92	138.7	77.4		+ 9.36
		17.7	26.8	55.5	100			
4.7	151.8	24.48	52.6	76.92	154	86		— 1.5
		15.9	34.1	50	100			
8.87	51.68	15.45	29.26	—	44.71	25		+ 15.7
		34.5	65.5		100			
8.87	51.68	15.45	34.13	—	49.58	27.7		+ 4.2
		31.15	68.85		100			
7.7	103.36	15.9	25.75	64.8	106.45	59.35		— 2.9
		14.95	24.2	60.85	100			
7.7	103.36	15.9	30	64.8	110.7	61.75		— 6.6
		14.4	27.1	58.5	100			

AI

COMPARISON BETWEEN THEORETICAL AND

Experiment No.	Track details				Ballast conditions	
	Torsional coefficient of fastening	Type of fastening	Length of misalignment	Misalignment	Nature of ballasting and grading	I l re
	C $\left(\frac{\text{ton in}}{\text{rad}^{1/2}}\right)$		l (ft)	q (in)		W d (
21	16·3*	10/3	32	0·67	1·5in uncompacted ballast under sleepers only	
	19**		32	0·67		
29	32·6*	10/3	25·2	0·5	1·5in uncompacted ballast under sleepers. Full boxing, no shoulder	
	38**		25·2	0·5		
34	32·6*	10/3	30	0·7	Boxing and 9in shoulder	
	38**		30	0·7		

* Taken from torsion test graphs.
** Taken from lateral moment of resistance graphs.
E = 13,100 tons/sq.in.
I_s = 19,34 in^4.

nued)

ING TEST RESULTS. — **Timber sleepers at 31 in spacing.**

Dynamic buckling load							Difference between experiments and theoretical buckling loads (%)
. dynamic obtained rom experiments		Max. dynamic obtained from theoretical calculations					
np. se	Corres. max. dynamic load	Carried by rails	Carried by fastening	Carried by ballast	Total	Corres. temp. rise	
F	P (tons)	$\pi^2 EIs/l^2$ tons (%)	$\frac{\pi^2 C}{16\,D}\sqrt{\frac{\pi l}{q}}$ tons (%)	Wd. $l^2/q\,\pi^2$ tons (%)	P tons (%)	°F	
	100·13	16·9 16·32	13·9 13·43	72·75 70·25	103·55 100	57·75	— 3·3
	100·13	16·9 15·96	16·22 15·34	72·75 68·7	105·87 100	59	— 5·4
·15	176·0	27·3 15·5	28·35 16	120·8 68·5	176·45 100	98·5	— 0·2
·15	176·0	27·3 15·12	33 18·23	120·8 66·65	181·1 100	101·2	— 2·8
	145·35	19·27 12·15	26·2 16·55	113·6 71·3	159·07 100	88·8	— 8·6
	145·35	19·27 11·8	30·54 18·7	113·6 69·5	163·41 100	91·17	— 11·1

APPENDIX 5

THE ULTIMATE BUCKLING LOAD OF TRACK WITH VARYING SLEEPER SPACINGS.

Type of fastening	Torsional Coeff. C.	Ultimate buckling load (tons) Sleeper spacing					Notes
		24/60ft	25/60ft	26/60ft	27/60ft	28/60ft	
109lb F.B. Rail. Timber sleeper							
10/3	32·6	269·8	279·4	288·4	279·9	307·4	Coeff. from torsion test
10/4	38·4	276·4	286·2	295·5	305·3	315·1	do.
10/6	44·8	283·7	293·8	303·4	313·5	323·6	do.
4/2	42·5	281·1	291·1	300·6	310·5	320·5	do.
4/4	46·5	285·6	295·8	305·4	315·6	325·7	Coeff. from M. of R. test
3/2	65	306·0	317·2	327·5	339·9	350·0	Coeff. from torsion test
3/2	62	303·2	314·1	324·5	335·4	346·2	Coeff. from M. of R. test
15	39	277·1	287	296·2	306·1	315·9	Coeff. from torsion test
15	55	295·2	305·9	315·9	326·3	337·0	Coeff. from M. of R. test
7	45·5	284·5	294·6	304·2	314·3	324·5	Coeff. from torsion test
109lb F.B. Rail. Concrete sleeper							
14	10·7	343·0	355·5	368·0	380·0	392·5	Coeff. from torsion test
23	17·3	350·4	363·3	376·2	388·3	401·2	do.
6	58·3	386·7	401·5	415·5	430·0	444·0	Coeff. from M. of R. test
18	32·6	367·9	381·4	394·9	407·9	421·4	Coeff. from torsion test
20	87	429·5	445·5	461·9	477·1	493·4	do.
9	38	374·0	387·7	401·6	414·8	428·6	do.
16	14·5	347·3	360·0	372·7	384·8	397·5	do.
16	21·5	355·2	368·2	381·3	393·8	406·7	Coeff. from M. of R. test
11/4	38·4	374·4	388·2	402·1	415·3	429·1	Coeff. from torsion test

APPENDIX 5 *(continued)*

THE ULTIMATE BUCKLING LOAD TRACK WITH VARYING SLEEPER SPACINGS.

Type of fastening	Torsional Coeff. C.	Ultimate buckling load (tons) — Sleeper spacing					Notes
		24/60ft	25/60ft	26/60ft	27/60ft	28/60ft	
B.S.95R. B.H. Rail. Timber sleeper							
24/3	89·4	244·4	253·5	262·3	272·3	281·0	Coeff. from M. of R. test
24/2	87·9	242·8	251·8	260·6	270·6	279·2	do.
24/1	78·9	233·4	242·1	250·5	260·0	268·2	do.
24	52·1	205·5	213·0	220·3	228·6	235·7	do.
B.S.95R. B.H. Rail. Concrete sleeper							
19/W	55	290·6	301·7	312·3	324·5	335·0	Coeff. from torsion test
19/S	68	304·2	315·8	327·0	339·8	350·8	do.
24/2	44·2	279·4	290·0	300·2	311·9	321·9	Coeff. from M. of R. test
							(Still under investigation)

Formula used: $Pb = \pi^2 EIs/l^2 + (\pi^2 C/16D)\sqrt{(\pi l/q)} + Wd\, l^2/Dq\, \pi^2$

Conditions assumed: 1 = 20ft F.B. Rail
17ft B.S. 95. R. Rail. $q = 1/4$in

Ballast resistance: Full ballasting with 9in shoulder. Uncompacted

W*d* (Wooden sleepers): 0·244 tons/sleeper.

W*d* (Concrete sleepers): 0·37 tons/sleeper.

E = 13,100 tons/in^2

I = 19·34in^4

FB.

I = 8·18in^4

BH.

APPENDIX 6

Dynamic and static creep resistance machines.

Static creep resistance machine.

The static creep test machine consists of a hydraulically operated ram mounted on a frame (figs. 13 and 14). On this frame are arranged four pairs of rollers between which a short length of rail can be guided so that the longitudinal line through its centroid coincides with the axis of the ram. The rail is mounted on a sleeper which is prevented from moving laterally be a rocking plate simulating the reaction produced by the ballast in the cribs.

Fig. 13. — General view of the static creep resistance machine.

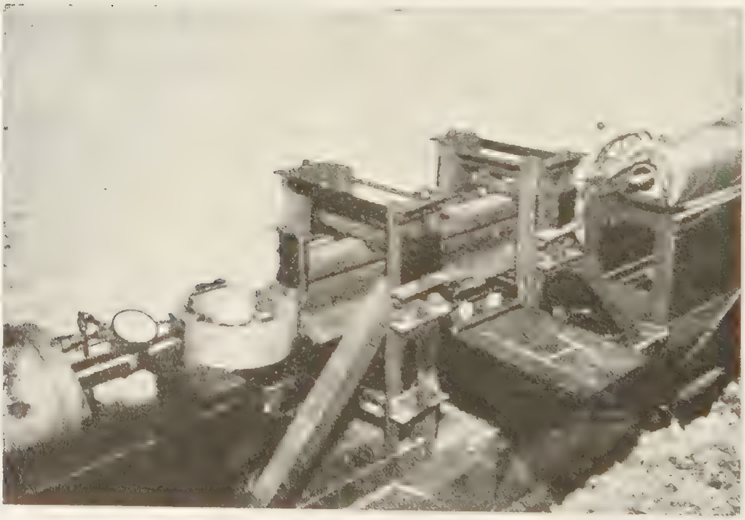


Fig. 14. - Close-up of a length of rail in the static creep machine.

The rollers mentioned above are necessary to resist the couple produced by the force

from the ram and the reaction from the sleeper, without undue friction forces influencing the reading on the proving ring. The hydraulic mechanism is similar to that described for the torsion machine, and again a proving ring is used to measure the load applied whilst dial gauges are used to record the movements which take place.

Dynamic creep resistance machine.

Both the sleeper loading and rail deflections, i.e., the precession wave, which occur due to a 0-6-0 locomotive with 10 ton wheel loads, have been calculated for varying formation stiffnesses and types of track. The dynamic machine reproduces those of 109 *lb/yd* FB rails on timber sleepers at 2ft 7in centres and a stiffness of bed normally of 60 tons/in deflection. No account of hammer blows is taken.

Tests are conducted on a single half sleeper-baseplate-fastening assembly with a short length of rail slightly longer than 2 ft 7in (figs. 15 and 16). This assembly is supported by a roller bearing plate which is in turn supported on four torsion bars. The load deflection characteristics of these bars can be altered and represent the elasticity of the bed; they are normally set to give 60 ton in deflection.

Movements are imparted to the rail by two hydraulic rams connected to it at either end via two strain gauge load cells and universal connections. Two cams are used to control the rams and these are driven by a hydraulic motor. Each of their revolutions produces movements of the rail equivalent to those which would be imparted to it by a 0-6-0 locomotive covering a distance of 16 sleepers. A 10 hour period of continuous running at 200r.p.m. of the cams is thus equivalent to forty locomotives per day over a period of 5 years.

Each test of an assembly covers 50 hours on the machine equivalent to 25 years on the track. During each 50 hour test the assembly

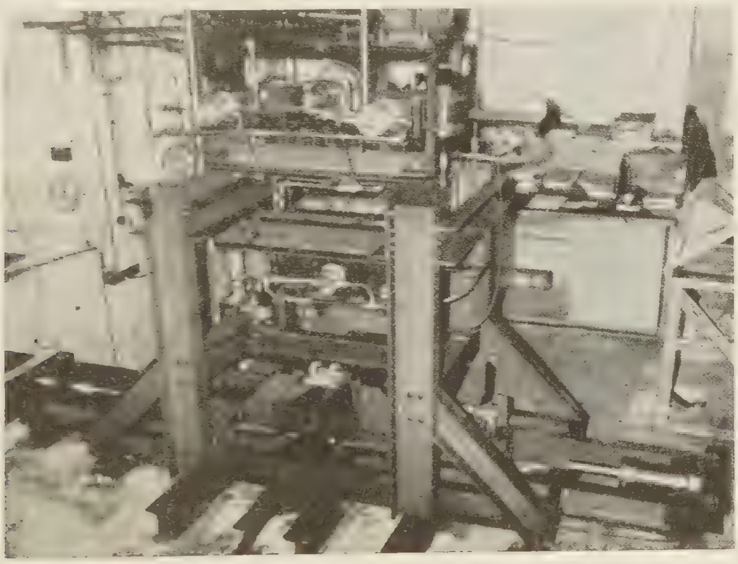


Fig. 15. — The general arrangement of the dynamic creep resistance machine.

is tested at five hourly intervals for static and dynamic creep resistance.

This is done by applying lateral forces to the sleeper via roller mounted plates carried in a U-shaped frame clear of the vibrating assembly under the roller bearing plate supporting the sleeper. The loads are applied to this frame via proving rings from hydraulic rams which are controlled independently of the vertical rams. The rail is prevented from moving along its axis during the creep tests.

The strain gauge load cells mentioned earlier are used to observe the loads applied to each end of the rail through an oscilloscope thus enabling an overall check to be made of the functioning of the dynamic creep resistance machine.

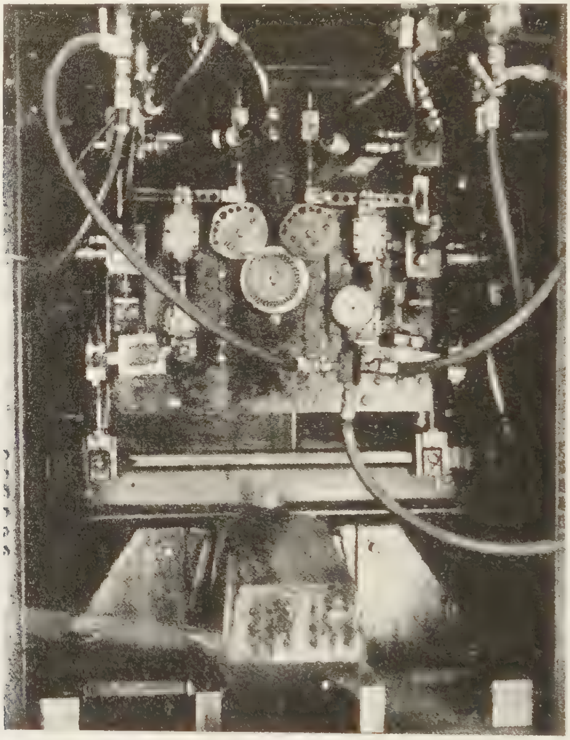


Fig. 16. — Close-up of the machine showing a length of rail mounted on a sleeper.

[656 .212 .5 (52)]

A theory of high efficiency marshalling yards.

New type of track layout in herringbone pattern,

by Yukio TANAKA and Minoru HARADA.

(*Japanese Railway Engineering*, March 1961.)

1. INTRODUCTION.

Because the necessity of modernizing transportation facilities as a result of the sharp increase in freight traffic recently has become apparent, the correct siting of freight stations and marshalling yards, the possibility of either merging them or abandoning them and the modernization of track layouts and facilities are now being studied.

Some of the results of such studies are being put into practice on a priority basis.

As to the modernization of yard facilities, a group of speed control devices such as the car accelerator, the car retarder, and the car stopper, communications apparatus such as facsimile telegraphy, the teletype and industrial television (I.T.V.), and route control systems such as automatic classification, are all functioning effectively today.

The operation of a marshalling yard may be classified chiefly into two categories i.e. the break-up operation and the make-up operation. Arranging the cars assigned to a specified train and the caboose, shifting cars loaded with L.C.L. to the relay track, storing the arriving and leaving cars and empty cars, shunting cars to be inspected and repaired and the special forwarding of cars — all these operations come under marshalling yard operations.

Inasmuch as the break-up operation is comparatively simple, it can be readily covered by a program of automatization and, as a result, in the oversea railways there are now many marshalling yards which are equipped with automatic classification and automatic speed control devices, but not including control by accelerator.

However, the make-up operation is not so simple and it is difficult to include make-up in an automatization program so long as the shunting operation is carried out under the present system of track layout. The make-up operation is far less efficient than the break-up operation. For instance, while one shunting engine takes charge of the entire break-up operation for the day, three shunting engines are used for the make-up operation and handle almost the same number of cars in a day as is handled in the break-up operation. The problem, obviously, is what measures can be taken to make the less efficient make-up operation more efficient, while partly improving the break-up operation, i.e. working out a system which will put both break-up and make-up on a single-flow basis. In other words, the problem involves completing the break-up and make-up operations as well as all incidental operations while keeping a given group of cars flowing in one direction from the receiving yard to the departure yard.

To solve this problem, it is necessary to study track layouts by which the break-up and make-up operations may be converted into a flow-system operation.

The JNR has studied such a track layout in detail and, after numerous tests and experiments, is now prepared to put it into practice.

With this new type of track layout, only one break-up operation is sufficient to complete the required number of make-up, and it has been assured that this new type of track layout has a capacity 3 to 5 times as large as the conventional track layout under equivalent surrounding conditions

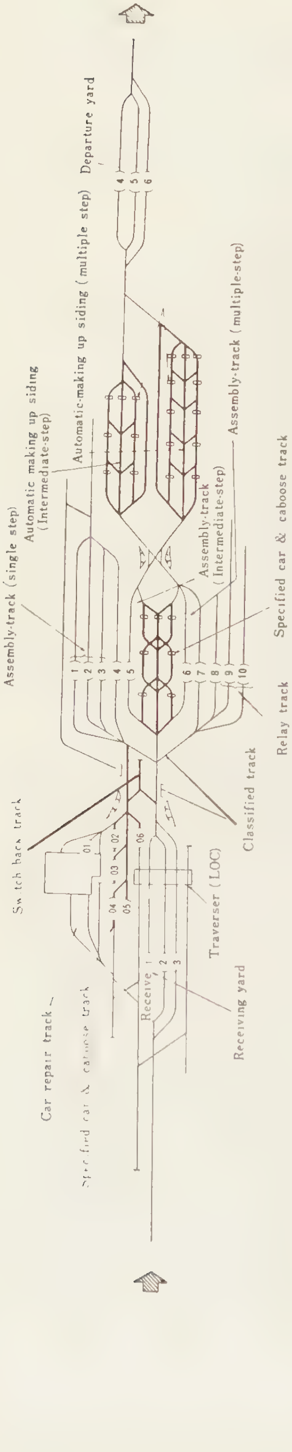


Fig. 1.

Fig 2

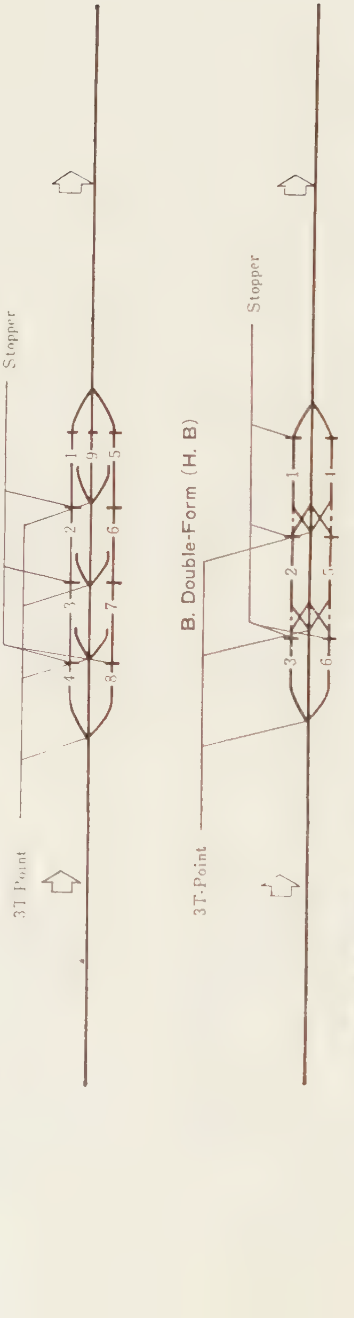


Fig. 3

such as right-of-way and the total length of track, etc.

The present paper has clarified the possibility of a high-efficiency marshalling yard, applying automation, on a smaller scale, to every step of the operation.

Although construction expenses for this special arrangement increase by somewhere around 20-30 % on one hand, the cost of marshalling is reduced sharply enough to redeem construction expense easily and the yard capacity for future demand is increased by two or three times that of conventional yards, so that improvement expenses are unnecessary.

are to be arranged in a specified order and the double type is used, as well as for the above purpose, for drawing out the car assigned to a specified train, and the caboose, at random.

However, the track layout exclusively designed for the drawing out operation i.e. the track for classifying the car assigned to a specified train has crossings only, eliminating the part shown with the broken line in the figure.

Figure 3 shows a track layout which has been hitherto used for making up a train and it is used in the following manner.

Making-up track in « Herringbone » pattern.

2. TRACK LAYOUT OF NEW TYPE IN THE « HERRINGBONE » PATTERN.

1) Construction.

The construction of the track layout consists of 3-throw points, a spring point, stopper and an accelerator. As a whole, the track layout is of the « herringbone » pattern. The entire track layout is provided with a balancing grade for a speed of 7 km/h (2 ‰ grade in JNR) and the storage tracks on both sides have a crossfall of 10-20 mm with respect to the passing track.

2) Types.

The track layout may be broadly classified into single and double types (cf. fig. 2 A, B). The single type is used for making up a train, of which the cars

In the case of figure 3 A, supposing nine cars, 8, 7, 4, 2, 3, 5, 1, 6 and 9 have been drawn out to make-up a train arranged in a specified order, three classification tracks are used, because it is a nine-step make-up, i.e. $\sqrt{9} = 3$.

In figure 3 A cars 1, 4 and 7 are led to track (1), because $x \equiv 1$ (mod. $\sqrt{9} = 3$), cars 2, 5 and 8, to track (2), because $x \equiv 2$ (mod. 3) and cars, 3, 6 and 9, to track (3), because $x \equiv 3$ (mod. 3), and if a shunting engine goes into the tracks, (1), (2) and (3) in turn and draws out the respective groups of cars, the car arrangement becomes 3, 6, 9; 8, 2, 5; 7, 4, 1 as shown in figure 3 B. Then, shifting cars 3, 2 and 1 to track (1), cars 6, 5, and 4, to track (2) and cars 9, 8 and 7, to track (3) respectively and further shifting the cars from track (1) to tracks (2) and (3) in turn, the car arrangement in the order of 9, 8, 7, 6, 5, 4, 3, 2, 1 is obtained.

In addition to the above, there are several other shunting methods which are more or less similar. In all cases, the drawing out and assorting are conducted twice or more. In this case the aggregate number of cars assorted is 2 × 9 = 18. In fact, in the Shintsurumi shunting yard (on the Tokaido line) it takes nearly 40-60 min to finish the arrangement of 45 cars, in 13-15 steps, in the order of stations, the aggregate number of cars assorted exceeding 100.

In this case the stopper is kept upright and thus catches the car which has entered. As described above, no matter in what order the cars enter the track, they can be put in the pockets of the storage tracks of respective destinations by using the passing track, without being interfered with. In other words the pockets of each storage track and the main track of the herring-bone type layout are connected in parallel with respect to the passing tracks, and each of these storage tracks is connected in

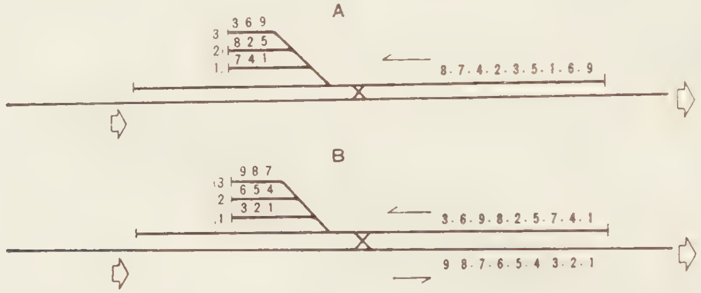


Fig. 3.

series with each other in order to arrange the cars in order. Thus, if the cars or train of cars which entered the track are drawn out one after another by keeping the stopper down, the car arrangement in the required order can be obtained. In other words, the train make-up is completed with the aid of one break-up operation. If, however, the number of cars that enter a pocket is too many for its effective length, the connection is previously made with an adjacent pocket either ahead or behind, making the two pockets one storage section. In this case, the entering point for the rear pocket is locked in normal position. However, in this case it must be taken into consideration that the number of steps of arranging the cars in order is reduced by one. The number of storage track pockets to be previously prepared is the maximum number of steps involved.

The assorting of the designated cars and adding them to certain specified trains respectively are now carried out in the following manner. There is one track set aside for classing by direction, on which the designated cars only are assembled. From this track the cars are drawn out in the order of the trains to be made up. However, other cars are incessantly coming down from the hump, and the cars cannot be drawn out any more than two or three trains, resulting in continuous shunting over a short period of time. Consequently the shunting efficiency is very poor.

3) Shunting operation.

i) Single type (tracks for arranging cars in order) (fig. 2 A). Cars which have entered the classification track one after another proceed to the storage track of the designated number, by pushing open the spring point and passing along a passing track, which is a part of the herring-bone layout.

ii) Double Type (tracks for arranging cars in order, receiving car individually) (fig. 2 B).

This type of track layout is, of course, able to arrange cars in order, but it is used when a car from the hump is to be coupled to a specified train prior to another car which left the hump earlier. In other words, it is a classifying tracks for specified cars. The handling of the cars that are designated for special trains has been hitherto extremely troublesome, drawing-out and shunting being carried out every two or three hours, because such designated cars come down from the hump one after another. In other words, such an operation deals with a comparatively small number of car-groups and yet requires considerable time for many making-up processes. If, however, the double type of track layout is used, cars can enter and leave the pocket independently. As a result, the conventional classifying operation for designated cars can be eliminated. The stopper is set up-right to catch a specified car and it is turned down to release the car. In this type of track layout each storage pocket is arranged in parallel with respect to the passing track and the pockets are connected also in parallel with each other.

4) **Performance.**

The result of the making-up performance test of the new type of track layout, which was conducted with a model, has revealed that it can complete the operation with only one break-up and the time required for making-up is almost constant regardless of the number of make-up steps, while with the conventional type of make-up track the drawing-out and breaking-up are carried out at least twice for the cars as a whole and the operation is not only complicated, but also is affected by the skill of the shunter. The time required for making-up markedly increases with any increase in the number of making-up steps (fig. 4).

Model experiment.

Prior to putting the present theory into practice, various experiments were conducted for the purpose of studying the performance, effects and what the operation covers, and the following is a brief description of the experiments.

The model track layout used for this experiment was of H-0 gauge (i.e. scale : 1/80) and installed on a table, 90 cm × 120 cm. A control-desk was also prepared. These are so arranged that they may handle the preparation of automatic point program, the stopper, the point, the switch, the track indicator board, the speed control of the shunting engine, the

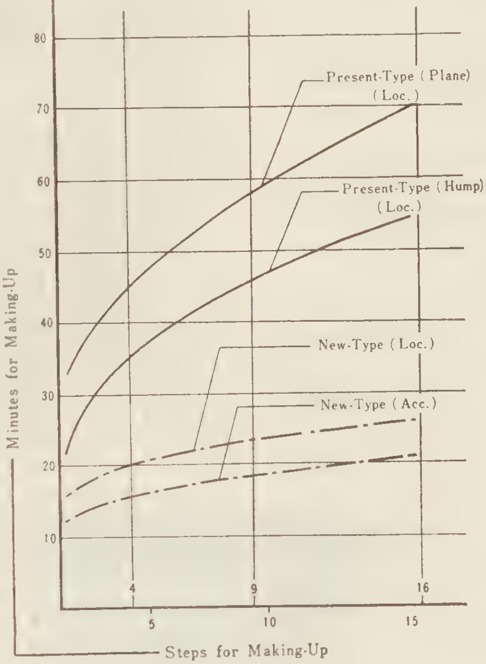
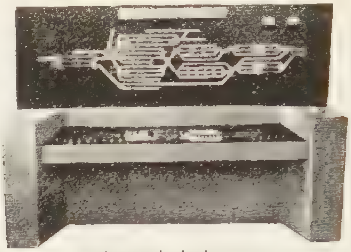


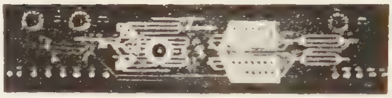
Fig. 4.

brake adjustment of the car-retarder, the switch of traversing by the servo-mechanism of the traverser, etc. The model shows only one side of the track layout covering the area from the receiving yard to the departure yard, and it is a model of the all-step-and-all-process automatic yard, designated « high performance yard of double type track layout ».

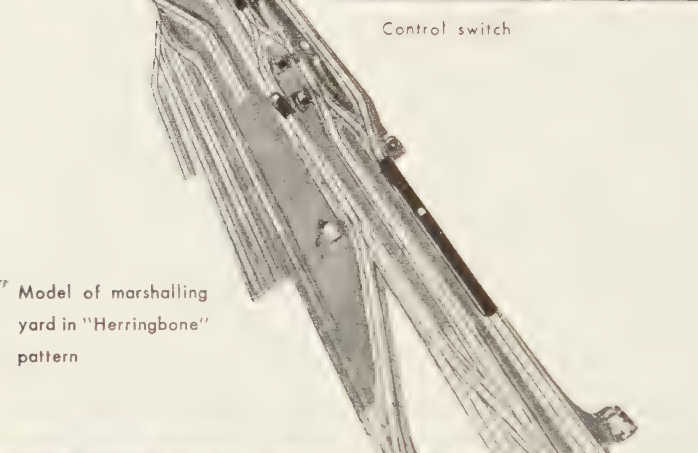
The breaking-up is carried out automatically by preparing a specified program.



Control desk



Control switch

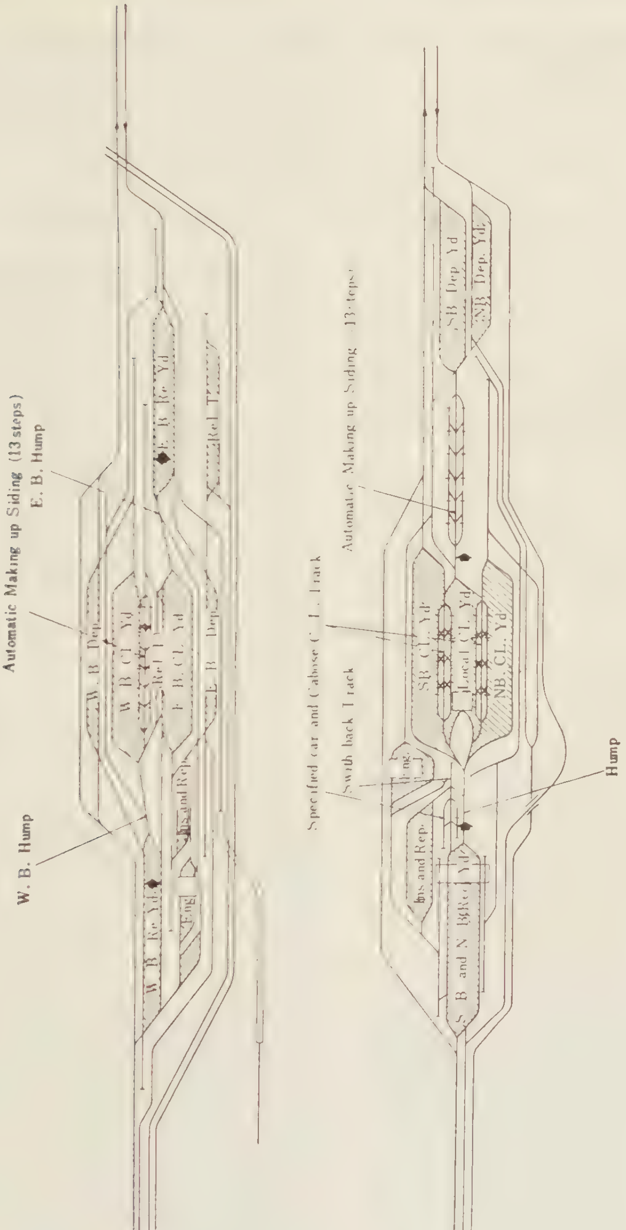


Model of marshalling yard in "Herringbone" pattern

Memory relay for arranging cars in order

However, the caboose, the specified car and the car to be inspected and repaired which are to be assembled by a single step, enter the switch back track coming down from the hump and they are classified by the single track of the new type layout. When the making-up is carried out on the single-step assembling track later, the cars enter the specified assembly track by means of the accelerator and the train is made-up automatically.

The cars that entered the inspection and repair track are transferred back to the receiving yard again after the inspection and repair and ride on the flow of automation, i.e. the flow from the receiving yard to the departure yard. There is a group of tracks according to destination at the foot of the hump, and the tracks in the group include the one-step assembly track, the partial assembly track, the multi-step assembly track, and the specified car



Automatic Making up Siding (13 steps)
E. B. Hump
W. B. Hump
W. B. Dep.
E. B. Re. Yd
SB Dep. Yd
NB Dep. Yd
SB CL. Yd
Local CL. Yd
NB CL. Yd
Specified car and Caboose C. L. Track
Switch back Track
Hump

Fig. 5.

Type of yard	Land	Kilometrage of track in the yard	Capacity (car/day)					Shunting locomotive (actually worked)	Number of workers (direct)	Operation by shunting locomotive
			Break-up	Making-up						
				One step	Interim step	Multi-step	Auxiliary			
Conventional	$50 \times 10^4 M^2$	45 KM	6 000	3 500		2 000	500	8	450	Automatic breaking-up
New	$50 \times 10^4 M^2$	45 KM	10 000	4 000	4 000	3 500	300	4	250	Automatic making-up

classification track (layout of new system, double type), and at the lower part of the multi-step assembly track there is installed a track according to the new system (single type). It is so arranged that the so-called arrangement in order of stations may be automatically carried out and the departure track is laid on its drawing out side. As a whole it is so arranged that the operation may be conducted automatically along a uniform flow from the receiving track to the departure track (fig. 1 and photos).

In addition to the present test model, a model of the conventional making-up yard was built by its side for purposes of comparison, and the actual values have been obtained from the values derived from the comparison test through conversion.

3. CONCLUSION.

Generally speaking the system of track layout is naturally different according to the number of cars to be handled and local traffic conditions. However, under the condition that a yard of some total kilometrage is set up on the same site, the advantage of the new system of track layout over the conventional system may be summarized as follows :

1) the new system has twice the operational capacity of the conventional system, or even more. (The making-up capacity alone is 3 to 5 times);

2) shunting cost are reduced to half or even less those of the conventional system;

3) every aspect of the shunting process can be automatized;

4) although the construction cost of a yard built according to the new system is higher by 20 %-30 %, it can be readily depreciated;

5) it is easy to design a yard according to the new system regardless its size-large, medium or small.

Beside the above advantages, it is also feasible to apply the track layout of the new system to a single spot in the existing freight car transportation system. Even in the event that the break-up capacity has been arranged to balance with it and the receiving and departure tracks have corresponding capacities, respectively, it can absorb cars that have been handled by a related shunting yard, because the making-up capacity of the new system as applied to a single spot is large enough. Therefore, the new system of yard track layout is considered a great help for the amalgamation or elimination of existing shunting yards.

Figure 5 shows two examples of a medium-sized shunting yard to which the new system has actually been applied. They both are able to handle 5 000-7 000 cars a day.

[656 .25 (52)]

Automatic train control system,

by Hajime KAWANABE.

(Japanese Railway Engineering, March 1961.)

1. Introduction.

Since trains are to run at high speed and at a high traffic density on the new Tokaido trunk line, it is obviously vital to ensure safe and smooth operation, by means of signalling. This means that signals on the new Tokaido trunk line cannot rely on the wayside signal system alone, but must be the safest and most reliable system combining the cab signal and the automatic train control system.

With this in mind, the first trial manufacture of a 5-indication automatic train control system was started in March, 1959. The second trial manufacture of a 7-indication automatic train control equipment was made exactly one year later, in March, 1960. Service test gave excellent results, and at present a third trial manufacture is under way.

In the following article, a rough outline of the experimental 7-indication automatic train control equipment will be given.

2. Operation system on the new Tokaido trunk line.

The operation system on the new Tokaido trunk line is being generally planned as following. The maximum speed of the passenger trains will be 200 km/h (250 km/h eventually), the maximum speed of freight trains is 150 km/h, and minimum train interval of limited express trains will be 5 minutes.

Let us assume that the rate of speed reduction from 200 km/h to 150 km/h is 2 km/h/s, the rate of speed reduction from 150 km/h to stop is 3 km/h/s (future rate of speed reduction from 250 km/h to 200 km/h would be 1.8 km/h/s), the error of the speed checker is 3 %, and the braking dead time is 4 seconds (2 seconds for signal aspect change, 2 seconds for braking force to actually work).

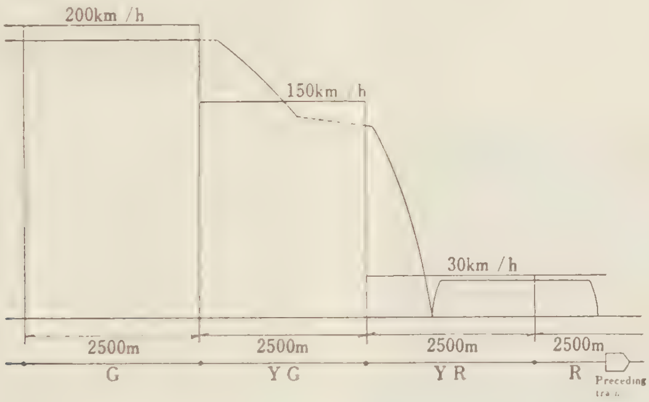


Fig. 1. — Speed curve when a train stops between stations.

Let the relation between the limited speed and the cab signal aspect be 200, 150, 110, 70, 30, 30 km/h and 0 km/h

respectively for G, YG, Y, YY, YR, R and RR. The relation of cab signal and train speed in case of the train stopping between stations, as shown in figure 1, is founded on the 4-indication principle but when speed limit sections (110 km/h and 70 km/h) are included on the way, the 5-indication or the 6-indication principle becomes the basic principle. Again, the relation between the cab signal and the train speed when stops are made at stations is shown in figure 2. At the station a 70

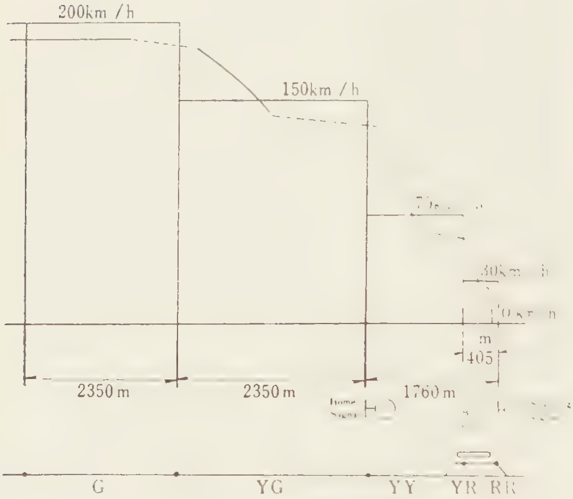


Fig. 2. — Speed curve when a train stops at a station.

km/h speed limit is established at the turnout point, B-point established at a spot 405 m before the home and the starting signals, and an absolute stop signal (RR) is established at a point 80 m before the starting signal to prevent over-runs.

3. Track circuit.

It has been decided that the wayside signals on the new Tokaido trunk line will be only home signals and starting signals, and the wayside signals between stations will probably be abolished. Between stations, track circuits of 2.5 km or 1.5 km are to be established as conditions dictate. As the new Tokaido trunk line will be electrified at 60 c/s (or 50 c/s), 25 kV alternating current, the track circuit system will be an audio-frequency track circuit in the vicinity of 1 kc frequency. Germanium transistors (silicon transistors in the future) are to be used in the transmitters and receivers, and the amplitude modulation of the audio-frequency carrier wave is to be made with the rectangular form low-frequency modulation wave.

Signal carrier frequencies of 700 c/s and 900 c/s are to be alternately distributed on the track circuit of the up-bound line in the 50 c/s section, while on the down-bound line 1 100 c/s and 1 500 c/s are to be alternately distributed. (In the third test manufactured equipment, 700 c/s and 900 c/s are to be adopted on the up-bound line of the 50 c/s section, 800 c/s and 1 000 c/s for the down-bound line.) For modulation frequencies, 10, 15, 25, 33, 41 c/s and 0 c/s (i.e., non-modulated) frequencies are to be used respectively for cab signal G, YG, Y, YY, YR and RR. The absence of signal current corresponds to R (stop). (In the third trial manufacture equipment, 5, 8, 12, 17, 23 c/s and 0 c/s).

In the transmitter, the oscillation frequency is changed by switching the C of the LC oscillation circuit. (The carrier frequency of the third test manufactured equipment is obtained by frequency multiplication of the 50 c/s overhead current frequency, while the modulation frequency is obtained from the LC oscillation or the beat of mechanical oscillator.)

In the standard track circuit (maximum ballast leakage conductance of 0.5 Ω /km), if a voltage of 2.4 V (1 kc) is imposed between the rails of the sending end, a voltage of over 0.03 V is transmitted to the rails at the receiving end, 2.5 km away. In the receiver, selective reception of the respective carrier frequencies is made through the bandpass filter, these frequencies are amplified, detected by the diode, passed through the voltage limiter for selection and amplification according to modulation frequencies, and excite the direct current relays. (In the third test receiver

the heterodyne reception system is being contemplated.) In this system, the frequency obtained by frequency multiplication of the 50 c/s overhead line current frequency is used to change the fore-mentioned carrier frequency in the vicinity of 100 c/s to an intermediate frequency of 100 c/s or 200 c/s, and then the demultiplied frequency is detected.)

The afore-mentioned systems are both of the DSB (double side-band) system but one system in the third test manufacture is now

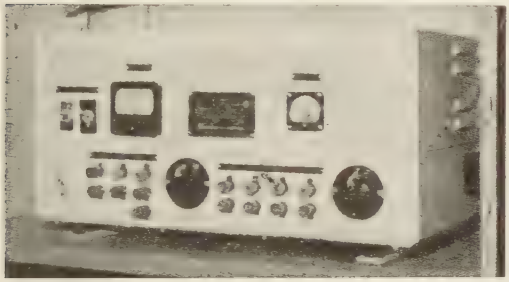


Fig. 3. — Transmitter of 7-indication track circuit.

being made on the SSB (single side-band) system by which only a single side-band is transmitted to the rails.

In this system the 50 c/s overhead line current frequency and the frequency obtained by its frequency multiplication is used as the pilot for the transmitter and receiver. For instance, the lower side-band of 550 c/s (600—50) and the upper side-band of 650 c/s (600+50) are alternately distributed on the track circuit of the up-bound line in the 50 c/s section, and the lower side-band of 550 c/s (600—50) and the upper side-band of 950 c/s (900+50) are alternately distributed on the track circuit of the down-bound line. For modulation frequency 5, 8, 12, 19, 26 c/s and 33 c/s are used, while modulation and demodulation, ring modulators and filters are used.

The outer aspects of the transmitter and receiver of the 7-indication system track circuit in the second test manufacture are as shown in figure 3 and figure 4. The number of indications is one less for the track circuit receiver, compared with that of the cab signal receiver. Moreover, the transmitter uses 15 transistors, while the receiver uses 37 transistors.

4. Cab signal.

The fore-mentioned signal current of the track circuit which flows in the rails is received by the receiving coils in the cab. Two horizontal type receiving coils are used and when the rail current is 50 mA, a voltage of 10 mV is induced in the cab. (In the third test equipment, a system of one vertical receiving coil is being tried.) The mechanism of the cab receiver is practically the same as that of the wayside track circuit receiver with the difference that in the cab receiver, the receiving coil and band-pass filter are respectively switched for use for up-bound and down-bound directions. (In the third test manufacture equipment, for instance, 700 c/s and 900 c/s are received for up-bound runs and for

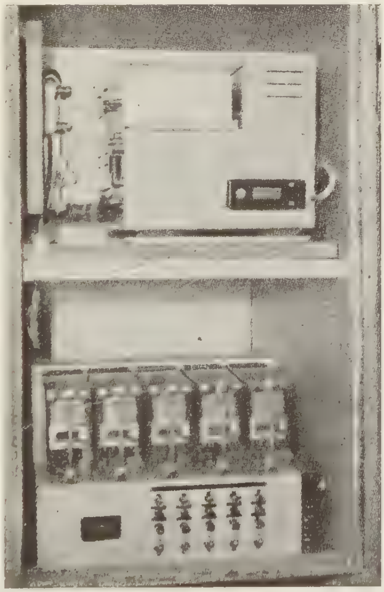


Fig. 4. — Receiver (upper) and relay box (lower) of 7-indication track circuit.

down-bound runs, 800 c/s and 1 000 c/s are received.)

The receiver and receiving coil of the 7-indication cab signal equipment in the second test manufacture are shown in figure 5 and figure 6. As far as the cab signal is concerned, the indicator which indicates the limited speed, as shown in figure 5, has been adopted instead of the colored light system. The cab signal re-

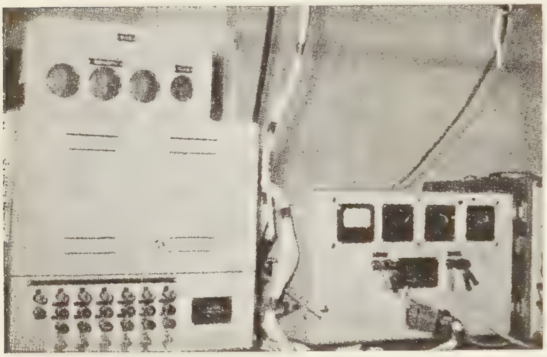


Fig. 5. — Receiver (right), relay box (left) and limited speed indicator (upper left) of 7-indication cab signal.

ceiver uses 44 transistors. The fore-mentioned track circuit and the test manufactured equipment for the cab signal are all to be used on 50 c/s sections, but equipment usable on 60 c/s sections can also be manufactured.

5. Speed checker.

The speed checker is a device by which one can easily check whether or not the speed at any optional instant is above or below the limited speed permitted in that certain section. In the second test manufactured equipment, the trial production of the electrical type, mechanical type and air micro type were made, the electrical type giving the best results in tests.

In the electrical system, an alternating current voltage proportional to the revolutions of the car wheel is generated by a generator connected to the car axle. This voltage is rectified into direct current and is compared with the direct current voltage proportional to the limited speed. Transistors are used in the electric circuits. (To make this equipment fail-safe, in the third test manufactured equipment, a check circuit was added to check wire disconnections in the circuit.)

As this is actually a new version of the conventional speedometer, it can also be used advantageously as a speedometer. The electrical type can easily compensate for error due to wearing out of the car wheels and is capable of cutting the overall error to within 2 %.

In the mechanical type, the revolutions of the car wheels are reproduced in the cab by the flexible shaft and are integrated every 2/3 seconds to defect mechanically the needle of a remodelled speedometer. Its mechanism is such that cams equivalent to the limited speed are attached to the revolving axis of the speedometer needle. When the train speed goes up, the cams, in turn, gradually open the relay contact point.

Fig. 6. — Receiving coils (left) and axle part of speed checker (right).

In the air micro system, the slit in the nozzle of a pneumatic tube is changed by the revolutions of the car axle and the pressure in the pneumatic tube is decreased in proportion to the speed. This pressure is compared with the standard pressure which is proportional to the limited speed.

The car axle part of the electrical speed checker in the second test product is shown in figure 6.

6. Automatic train control equipment.

Automatic train control equipment is a safety system which automatically keeps the train speed constantly below the limited speed even if the cab operator is at fault. As shown in figure 7, automatic train control equipment consists of a cab signal, speed checker, automatic control equipment and braking mechanism. The limited speed

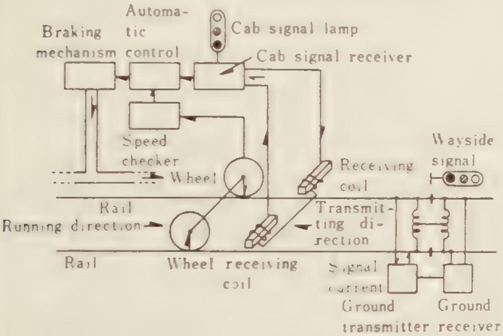


Fig. 7. — Composition of automatic train control equipment.

prescribed by the cab signal and the present speed indicated by the speed checker are compared, and if the latter surpasses the former an alarm is sounded, a red light goes on, and the automatic brake goes into action.

Test manufactures were made of two systems; namely, one in which the automatic control does not go into action if the operator uses the hand brake within three seconds after the sounding of the alarm, and the other in which the automatic brake immediately goes into action without the three seconds allowance time. The latter system is to be adopted on the new Tokaido trunk line. This system is actually a step in the direction of the automatization of train operation.

In the former, the alarm immediately stops when the operator brakes the car by hand, but the red lamp continues to be lit until the train speed falls below the limited speed, returning to white only when the train speed becomes lower than the limited speed. If the operator releases the hand brake while the red lamp is still on, the alarm goes on again and the automatic brake goes into action after three seconds. Both the bell and the whistle have been test manufactured for these systems.

A system in which the brake is released automatically when the train speed becomes lower than the limited speed, and another system in which the release is made only when the operator pushes a button, have also been test manufactured. The former is to be adopted on the new Tokaido trunk line. By a simple change of a part of the relay circuit, it can be so divised that the brake cannot be released until a temporary stop is made only for a permissible stop signal YR (limited speed 30 km/h). The external aspect of the automatic control equipment in the second test manufacture, as shown in figure 8, is of the all-relay type. The relay type is simpler in structure compared to the electronic type and besides being able to easily satisfy the fail-safe requirement, it is highly reliable.

Good results were obtained when the afore-mentioned automatic train control

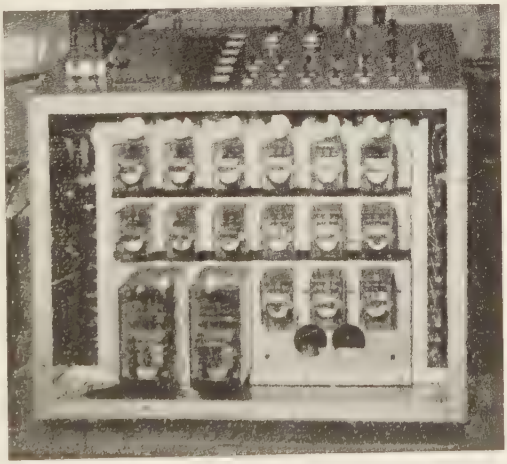


Fig. 8. — Automatic control equipment.

equipment from the second test manufacture was mounted on the MOHA 100 Type and 101 Type electric cars and tested on the Tokaido trunk line. An example of the speed curve at that time is shown in figure 9. However, in this case, the limited speed was changed to the four steps of 80, 50, 20 km/h and 0 km/h (absolute stop), and for the speed checker, an electrical system was used. The figure is an example of the system in which the automatic control goes into action immediately when the limited speed is surpased, and is automatically released when the car speed falls below the limited speed.

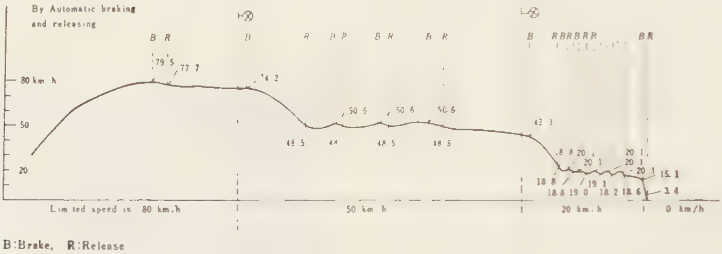


Fig. 9. — An example of speed curve adopted in service test.

7. Conclusion.

The automatic train control equipment which was test manufactured in March, 1960, is outlined above, but revisions have now been made and the third test manufacture is being made. It sould be completed toward the end of 1960 and service tests will be made. As the new Tokaido trunk line is to be electrified in alternating current and its traction current is expected to be 1 000 A, the interference voltage occurring from unbalanced traction current will become particularly large. Therefore, the track-circuits and cab signal equipment must be able to handle these efficiently, i.e., the relays of the track circuit and cab signal must be a system which will not cause instability due to the higher harmonics arising from the fore-mentioned interference current.

Moreover, with the exception of automatic control equipment of the relay type, the fore-mentioned systems are of the electronic type using many transistors, thereby making it imperative that the electric circuits be simplified as much as possible, the parts fully examined, and the reliability of the equipment improved. Studies are also being made on methods enabling automatic switching to emergency spare units when equipment fails, besides systems to concentrate ground equipment in one place.

[656 .222 .1 (54)]

Speeds of goods trains on Indian Railways,

by Jagjit SINGH,

Director Traffic (Transportation), Railway Board, New Delhi.

(*Indian Railway Technical Bulletin*, November 1960.)

A distinction is drawn between the concepts of average speed of goods trains on a single section and that of goods trains run on a group or aggregate of sections. Mobility potential of goods trains, defined as the percentage ratio of average speed attained and the optimum speed attainable under the prevailing conditions has been calculated for the years 1952 to 1959. The steady maintenance of mobility potential during the past four years at a level ranging between 84 and 86 as compared to the level of 81 attained during the previous two years is a testimony to the achievements of the Indian Railways.

Past discussions of speeds of broad gauge goods trains on the Indian Railways have been bedevilled by failure to appreciate the rather subtle distinction between the concept of average speed of goods trains on a *single* section and that of goods trains run on a *group* or *aggregate* of sections. When we have in view a single section, the average speed of goods trains during any assigned period is the ratio of total goods train miles accruing on the section during the period to the total goods train engine hours of the corresponding trains. Clearly this ratio is an excellent measure of the mobility of trains run on that section. Paradoxical as it may be, the situation alters altogether when we choose to deal with a group or aggregate of sections in an analogous manner. For when we compute the ratio of total train miles on a group of sections to that of their corresponding train engine hours, the ratio is *not always* a valid index of the mobility of trains on the aggregate of sections. For the sake of simplicity, consider a group of two sections. If the average speeds on each of these two sections remain constant during two periods, then the mobility of trains on the aggregate of two sections may also be deemed to remain constant. But more often than not the ratio we call the speed of trains on the two sections will change. Thus let m_1, e_1 and m_1' and e_1' be the train miles and train engine hours on the first section during any two periods and m_2, e_2, and m_2' and e_2' the corresponding values for the second section. Now if

$$\frac{m_1}{e_1} = \frac{m_1'}{e_1'} \quad \text{and} \quad \frac{m_2}{e_2} = \frac{m_2'}{e_2'}$$

then $$\frac{m_1 + m_2}{e_1 + e_2} \neq \frac{m_1' + m_2'}{e_1' + e_2'}$$

except in the very special case when the speeds on the two sections happen to be identical. Since speeds of trains on individual sections are ratios which are mostly not equal to one another and speed on the aggregate of these sections is a ratio derived from the former ratios by dividing the sum of their numerators by that of their denominators, the speed of a group of sections is apt to contain an element of spurious variation quite uncorrelated with the actual variation of mobility of trains of the group. However, if the number of trains run on each of the sections included in the group remains more or less constant or at any rate does not vary too much, the spurious element of variation that the speed index contains also remains constant. Since the judgement regarding the mobility of trains on the group of sections is based on a comparison of speeds during the different periods, the existence of a constant element of spurious variation does not seriously impair the utility of the speed index as a measure of the relative deterioration or improvement of mobility of

trains on the *group as a whole*. But when we enter a period of drastic changes in the number of trains run on some or all the sections included in the group, the spurious element of variation remaining no longer constant invalidates the use of speed as an index of train mobility of the group as a whole.

Now our economy having entered what the economists call the take-off stage some four years ago, there have occurred quite considerable changes in the services run on the various sections as will be seen from the following table showing the total goods train miles during the seven years 1952-53 to 1958-59.

TABLE I.

Year	Train miles (in thousands) All goods steam	Index
1952-53	49,992	100
1953-54	49,600	99 · 22
1954-55	52,442	104 · 90
1955-56	56,291	112 · 6
1956-57	59,220	118 · 46
1957-58	61,588	123 · 20
1958-59	60,547	121 · 11

It will be seen that goods train miles have increased by about 23 %, particularly during the past four years. This is an overall average but its actual distribution is most uneven. On certain railways, like for instance Western, the increase has been 50 % or more and when we break it down further into sections we find that the bulk of the increase following the biblical injuction " unto everyone that hath shall be given " has occurred over the busier sections where the utilisation was already close to capacity. Thus on the sections where the changes in the number and pattern of goods train services have occurred they have been very drastic. In a period of such drastic and radical changes, the arithmetic of the speed computation for a group of sections is such that the effect of additional trains introduced on overall speed of the group is at first sight paradoxical. When we consider a single section the effect of introducing one or more additional trains on it is invariably to decrease the average speed. But this is no longer the case when we envisage a whole group. It is a consequence of the theorem that percentage increase (or decrease) in overall speed of a group of sections is given by 100 times the difference between the ratio of additional train miles introduced to total train miles and that of the corresponding *additional* train engine hours to total train engine hours. To prove the theorem, consider a railway system consisting of n sections. Let the train miles accruing on these sections be $M_1, M_2, \ldots M_n$. Similarly, let the corresponding train engine hours be denoted by $E_1, E_2, \ldots E_n$. The speed on the entire railway system would then be equal to

$$S_1 = \frac{M_1 + M_2 + \ldots + M_n}{E_1 + E_2 + \ldots + E_n} = \frac{M}{E}$$

where $M = \sum_1^n M_r$ and $E = \sum_1^n E_r$

Now suppose one or more additional goods trains are introduced on some or all of these sections. Naturally therefore not only the train miles but the train engine hours would also increase. Suppose the new values of train miles on the sections are $M_1', M_2', M_3' \ldots M_n'$ and the corresponding values of engine hours are $E_1', E_2', \ldots E_n'$. The new speed S_2 will now be equal to

$$\frac{M_1' + M_2' + \ldots + M_n'}{E_1' + E_2' + \ldots + E_n'} = \frac{M'}{E'}$$

$$= \frac{M + \Delta M}{E + \Delta E}$$

where ΔM and ΔE are the sums of the additional train miles and train engine

hours of trains introduced. Consequently percentage variation in speed would be

$$\frac{S_2 - S_1}{S_1} \times 100 = 100 \left\{ \frac{M + \Delta M}{E + \Delta E} - \frac{M}{E} \right\} \frac{E}{M}$$

$$= 100 \left\{ \frac{\Delta M}{M} - \frac{\Delta E}{E} \right\}$$

which proves the theorem stated. Naturally this percentage increase is positive or negative according as $\left\{ \frac{\Delta M}{M} - \frac{\Delta E}{E} \right\}$ is positive or negative or, according as

$$\frac{\Delta M}{M} > \text{ or } < \frac{\Delta E}{E}$$

or, according as

$$\frac{\Delta M}{\Delta E} > \text{ or } < \frac{M}{E}.$$

In other words, if the ratio of additional train miles to corresponding additional train engine hours viz. $\Delta M / \Delta E$ exceeds the pre-existing average speed viz. M / E the overall speed will increase otherwise it will decrease. This is yet another reason for the logical distinction between the speed of trains on a single section and a group of sections. This is also why we have to study in detail the breakdown of additional train miles introduced before we can say whether their introduction will elevate or depress the pre-existing average speed. If they accrue from slower moving trains like coal pilots, or industrial ore pilot or shunting trains so that the ratio of their train miles to their corresponding engine hours is below the average overall speed, then their effect would be to depress the overall average speed. The contrary will be the case if they accrued from faster moving trains. If, therefore, follows that we need to know a detailed breakdown of the additional train miles introduced into various categories like those contributed by coal and ore pilot trains, shunting trains and the faster through trains, etc. Now over the last seven years the train miles of all goods trains increased from about 50 million in 1952-53 to 61 million in 1958-59. A detailed census of how many of these extra 11 million train miles were contributed by each type of train would be too tedious to be practicable. And yet this is precisely what we must do to make a scientific appraisal of the effect of these additions on the average speed of goods trains. Fortunately, there is a way out of the difficulty. Let us classify the additional train miles into three main groups :

(i) Very slow moving coal and ore pilots which barely move 20 miles in 10 hours yielding an average speed of 2 m.p.h.

(ii) Slow moving trains or pilots like shunting and SQT trains with an average speed of 5 m.p.h.

(iii) Faster moving through trains with an average speed of 11 m.p.h. We adopt this figure as this was the average speed of through goods trains at the beginning of the seven-year period under review viz. 1952-53. We thus assume that the general body of through trains continues to move with the same average speed as seven years ago even though the adopted average is an over-estimate.*

Let us assume that a proportion p of the total of 11 million additional train miles belonged to category (i), a proportion p' to category (ii) and a proportion p'' to category (iii) so that $p + p' + p'' = 1$. Now if $11\,p$ million train miles accrue from very slow trains or pilots moving at 2 m.p.h. their corresponding engine hours e would clearly be $^{11}/_{2}\,p$ million train engine hours. Likewise the contributions of trains of category (ii) and (iii) to their train engine hours would be $e' = {}^{11}/_{5}\,p'$ and $e'' = {}^{11}/_{11}\,p''$ million train engine hours. If, therefore, follows

* The reason is that on saturated sections where bulk of the increase has taken place, it would be impossible to attain it due to the increased sensitivity of these sections to operational hazards like control failures, hot axles, engine, signal and point failures, etc. which exact a far greater toll now than previously. On newly opened lines like Dhalli-Rajahra which are lightly used this speed is equally impossible because the lines over long stretches are subject to severe speed restrictions like 10 m.p.h. or even less as they are still not consolidated.

that an addition of 11 million train miles would require an additional expenditure of ($^{11}/_{2}\,p + {}^{11}/_{5}\,p' + {}^{11}/_{11}\,p''$) million train engine hours. Now as it happens the average speed in 1952-53 was 10·4 m.p.h. so that the initial total of 50 million train miles was secured by an expenditure of 50/10·4 million train engine hours. Thus if the 1952-53 speed was 50÷50/10·4 m.p.h., then the new speed after an increase of 11 million train miles *should* be

$$\frac{50+11}{\frac{50}{10\cdot4}+\frac{11}{2}p+\frac{11}{5}p'+\frac{11}{11}p''}\ \text{m.p.h.}$$

$$=\frac{61}{\frac{50}{10\cdot4}+\frac{11}{2}p+\frac{11}{5}p'+\frac{11}{11}p''}\ \text{m.p.h.}$$

Hence the percentage drop in speed merely because of the total increase in train miles *without any deterioration in the standard of operation would be :*

$$\left[\frac{50}{\frac{50}{10\cdot4}}-\frac{61}{\frac{50}{10\cdot4}+\frac{11}{2}p+\frac{11}{5}p'+\frac{11}{11}p''}\right]\times\frac{100}{10\cdot4}$$

which can easily be seen to equal

$$\left[\frac{5\cdot2\,p+2\cdot08\,p'+0\cdot94\,p''-1}{0\cdot44+\frac{p}{2}+\frac{p'}{5}+\frac{p''}{11}}\right]\times\frac{100}{10\cdot4}$$

Table II below gives the values of this drop for various values of p, p' and p''.

TABLE II.

p	p'	p''	Percentage decrease
·01	·01	·98	·11
·05	·05	·90	4
·1	·1	·8	8
·2	·2	·6	15

This table shows that even when the percentage of additional train miles accruing from slow moving trains remains as low as below 2 % of the total *additional* train miles the overall speed is likely to remain practically the same, the percentage increase being only 1/10 %. But the moment this percentage begins to increase beyond the level of 2 %, the overall speed begins to drop almost catastrophically thus producing an *illusion* of a grave deterioration when in fact the quality of operation has at least remained of the same order of merit. Actually a vastly improved standard of operation is needed to retain the same statistical speed in view of the far greater sensitivity of the sections to operational hazards. But the mode of computation not only wipes out this improvement but also introduces an element of spurious deterioration. The magnitude of this deterioration begins to increase quite fast. It is 4 % if the percentage of additional train miles from slower trains becomes 10 % of the total increase reaching the staggering level of 8 % when the percentage of slower train miles added becomes 20 %. Now in 1958-59 the coal pilot train miles on the Eastern railway alone were 419,363 against 229,845 during 1952-53, that is, an increase of 189,518 which is 1·7 % of the overall increase of 11 million train miles. Adding to it the additional coal train miles of other railways we may assume the increase from the coal and ore train alone to be 5 %. At a rough but greatly conservative guess another 10 to 15 % would accrue from other slower moving trains like those carrying oversize consignments, shunting trains, pilots, etc., so that one could safely put down the contribution of type (i) and (ii) trains as lying somewhere between 10 to 20 %. If so, Table II shows that this feature alone would entail a fall between 4 to 8 %. Further, on the basis of assumptions underlying the calculation one may safely assert that the lower limit of speed decline on this account is about 6 %. Another 2 % would be entailed by the additional passenger trains introduced since 1952-53. This has been assessed as under :

We have seen above that the introduction

of additional goods train miles may or may not decrease the pre-existing overall average speed of goods trains depending on whether the ratio $\Delta M/M$ of the additional train miles introduced to the total pre-existing train miles is more or less than the ratio $\Delta E/E$ of the corresponding increase in the train engine hours to the total pre-existing train engine hours. This, however, is no longer true of the introduction of additional passenger trains. The reason is that while the additional passenger train on any section does not increase the *goods* train miles at all, the corresponding train engine hours of some or of all the pre-existing goods trains are enhanced. This naturally has the consequence of *always* increasing train engine hours without making *any* increase in the train miles so that the overall speed of goods trains is invariably depressed. The theorem proved earlier also enables us to compute the magnitude of this inevitable decrease. Making use of this theorem the Efficiency Bureau of the Railway Board calculated in 1956-57 that the introduction of additional passenger trains up to that time led to a drop of the following percentage in the speed of all goods trains on the following railways :

Central Railway	—
Eastern Railway	—
Northern Railway	1·83
Southern Railway	2·10
S. E. Railway	—
Western Railway	3·00

Averaged over all the railways, this works to 1 %. Taking into account the additional passenger trains introduced since 1956-57 one may hazard the guess that a fall of another 1 % would occur as a result thus making a total fall of 2 % on this account as mentioned above. We thus see that these two factors alone — the introduction of additional passenger trains and the contribution from the slower moving trains being 10 to 20 % of the additional train miles introduced — would lead to a fall of about 8 % in the speed of goods trains which is the lion's share of the actual drop (10 %) that the goods trains have registered during the past seven years.

This conclusion, which is quite contrary to the general impression prevailing, is fully supported by other considerations equally cogent.

As we have seen, the speed of a group of sections in a period of rapid change is subject to a whole complex of variations of various sorts. Not all these multifarious elements of variation can be quantified. As we have seen, the element of spurious variation caused by the changes in the quantum and pattern of train miles on the Indian Railways cumulatively produces a very significant fall. In addition there are the falls sparked by more intensive utilisation of sections already working to saturation or near saturation levels. Under such circumstances, if speeds of goods trains are to be studied, such study must fix itself against the background of the flux caused by all these factors. But how, one may enquire, are all these factors of flux to be quantified. As we have seen, we could so far quantify only two factors viz. the fall caused by the increase in slow moving trains like coal pilot and ore trains and the introduction of new passenger trains which together result in a fall of about 8 %. For the rest there is only one way out of these difficulties. It is that we assess the performance of a railway as a whole by comparing its actual speed with the optimum overall speed possible under ideal conditions when the whole railway is *imagined* to run with master-chart precision and efficiency. No doubt this ideal state of affairs is in practice unattainable. No matter. We may nevertheless figure out what would be the average speed in case these ideal conditions could be secured. In other words, we *imagine* the railway to run as a perfect model and then calculate what the average speed as a whole would then be. A criticism of this approach is that the calculation of optimum speed involves a simplification of a situation which in practice is very complex. For instance, it assumes that the number of both goods and passenger trains run remains fixed whereas in actual practice, there is a good deal of day-to-day variation even in the number of passenger trains run as on some sections some passenger trains like the de-Luxe trains do not run daily. If the

validity of this criticism is conceded, one may as well reject all trajectory tables on the ground that their calculation assumes gravity to remain constant during the flight of the projectile, disregards the radiation pressure of light rays and the perturbation caused by the varying distances of Moon, Mars and other planets. There is no end to complicating factors and to take account of them all is to negate the possibility of a solution. Every solution has to simplify the actual situation to a more or less degree so as not to make mathematics totally intractable. In making the simplification one needs only guard that the situation is not oversimplified. That the simplification suggested in this case does not materially distort the actual situation is seen from the fact that the minor fluctuations around the assumed sectional norms do not affect the ideal overall speed in any significant manner. Moreover the ideal speed is intended merely to function as a fixed background against which the shifting performance is to be set for purposes of appraisal.

This calculation of ideal speed is not difficult to make. All that is necessary is to consider each section separately, and calculate for it the train miles accruing daily and the corresponding train engine hours if every train ran according to schedule as plotted on the master chart, that is, under conditions of ideal operating efficiency. Thus, suppose t_i is the total train miles obtainable by running the full quota of goods services prescribed for any section i and e_i the train engine hours of the corresponding trains *according to the master charts*. For the railway as a whole the daily train miles accrued would be

$$\sum_1^n t_i$$

for an expenditure of $\sum_1^n e_i$ train engine hours.

The optimum speed of goods trains for the railway as a whole would therefore be

$$\sum_1^n t_i \bigg/ \sum_1^n e_i$$

A calculation made on these lines by the Efficiency Bureau in 1956-57 for the conditions *then* prevailing showed that the optimum speed of all goods trains on the Indian Railways was 11·5 m.p.h. For proper appreciation of the trend of speeds of all goods trains it would be necessary to calculate the optimum speed of all goods trains attainable under the conditions obtaining in each year. We could then compare the actuals obtained in any year with the corresponding optima attainable under ideal conditions prevailing at the time and expressing the former as a percentage of the latter. In this way we would be able to ascertain the extent to which the *mobility potential* or speed potential of goods train available at the time was actualized. We thus require the optimum speeds attainable in each of the four years prior to 1956-57 and the two years following 1956-57. As these calculations have not yet been made, we may hazard the following guess regarding these optima on the basis of increases in train miles shown in Table I. We observe that during the three years 1952-53 to 1954-55, train miles remained practically stationary. During the next two years, 1955-56 and 1956-57, the train miles rose by 13 and 18 % respectively.

TABLE III.

Year	Optimum	Actual	Percentage of optimum
1952-53	12 · 54	10 · 4	83
1953-54	12 · 54	10 · 2	81
1954-55	12 · 54	10 · 1	81
1955-56	11 · 4	9 · 86	86
1956-57	11 · 4	9 · 60	84
1957-58	10 · 94	9 · 28	85
1958-59	10 · 94	9 · 19	84

We may assume that the optimum speed or speed potential possible during the former three years, was, at least, 10 % *higher*. During the last two years of the period under review, when the train miles jumped by another 5 to 10 %, we may conservatively estimate that it was at least 4 % *lower*. Table III gives the average speeds expressed as a percentage of their corresponding optima during the seven years based on these assumptions.

This table clearly shows that actualisation of mobility or speed potential fell during the two years following 1952-53 by 2 % after which it began to rise peaking to 86 % during 1955-56. The steady maintenance during the past four years of the mobility potential at a level ranging between 84-86 compared to the level of 81 attained during the previous two years is in fact a measure of the Indian Railways' achievement which is not only masked but actually reversed if we merely look at the speed figures without a probe into their physical meaning. When it is realised that all the apparent drop in the speed of all goods trains that has in fact occurred is (as shown above) almost wholly accounted for as the inevitable aftermath of changes in the pattern of additional train miles accrued plus additional passenger trains introduced one may indeed marvel that the speeds have not deteriorated more. And yet this is no marvel to those who know from inside the saga of the railwaymen's incessant struggle to improve operating efficiency of the railways.

[625 .24 (73)]

REA express testing container cars.

(From the *Railway Locomotives and Cars*, May, 1961.)

Containerization in various forms is being investigated and utilized by REA Express in its intensive effort to develop a profitable method for handling small package shipments. REA Express, successor to the Railway Express Agency, has just begun an experimental operation, between New York and St. Louis over the Pennsylvania. Two newly developed container cars are being used.

One of these cars is a General American G-85 piggyback car equipped to handle twenty 212-cu. ft. Fruehauf containers. The other is a Pullman-Standard 85-ft. skeleton container car designed to handle sixteen 261-cu. ft. Trailmobile containers.

The ability to load and unload containers rapidly is an important feature of the new REA Express program to overcome problems associated with economical movement of small shipments. On the New York to St. Louis run, one or more containers are removed at Dayton, Ohio; Indianapolis, Ind., and Terre Haute, Ind. Containers removed at these intermediate points will be loaded with New York shipments and will again be placed on the cars when they return on their eastbound trips.

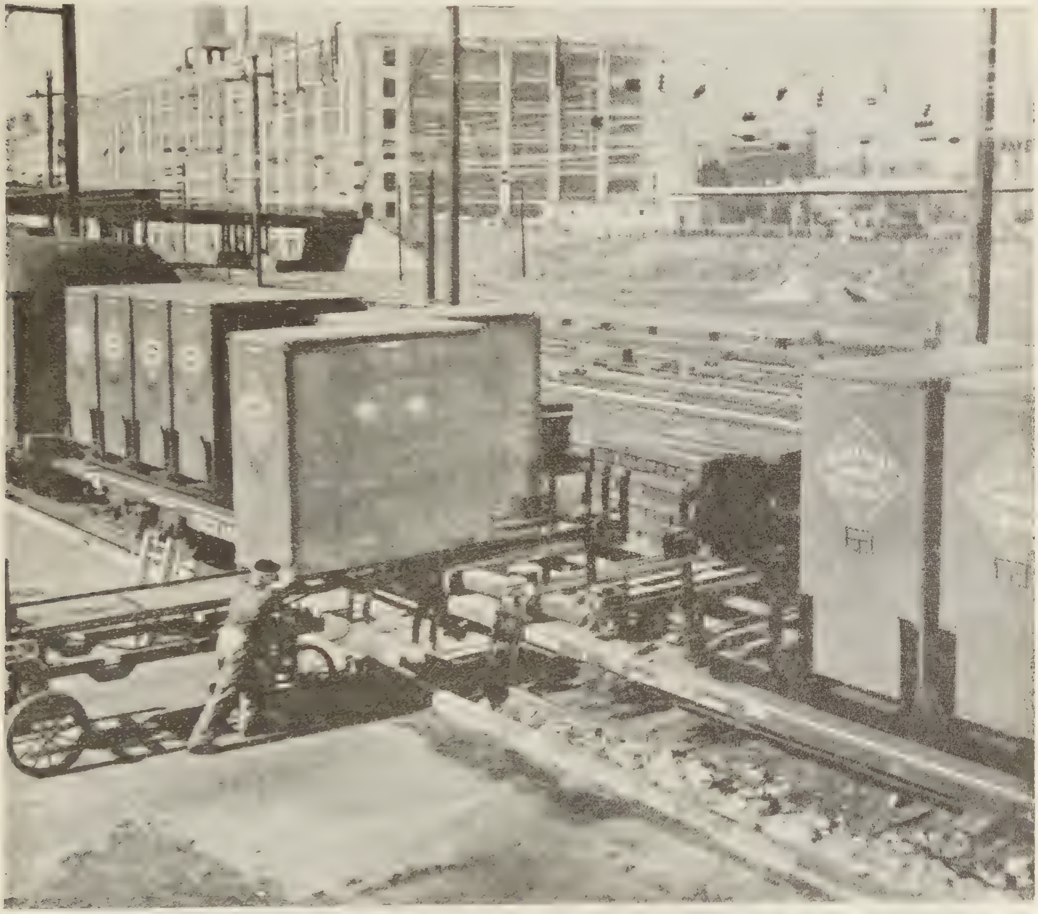
Necessary rapid handling at intermediate points is made possible by REA-designed hydraulic, variable-height platform trucks. Containerized express shipments can be transferred to and from fast passenger trains during brief stops.

Swivel casters on Fruehauf container make possible truck-to-car transfer and also permit moving the box on station platform.

The General American G-85 piggyback car accommodates four demountable REA container rack-cradles which are cushioned on the Clejan shock absorbers that are built into the deck of the car for cushioning trailers and containers in conventional piggyback service (R. L. & C., Oct. 1959, p. 27). This shock-absorbing mechanism

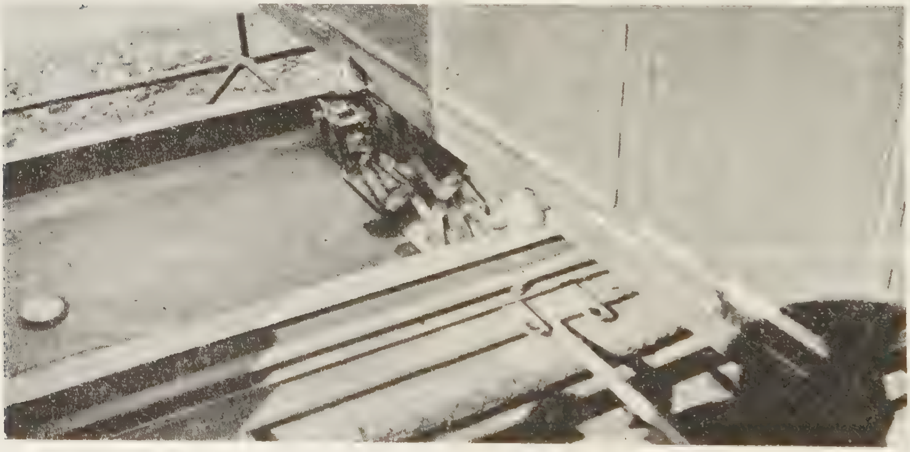
has a maximum of 11 in. travel in each direction. The car is not changed structurally for use in the REA Express operation. For passenger service, it has been equipped with steam and train signal lines. Complete with racks, the 85-ft. car's light weight is 71 000 lb.

The demountable rack-cradle, 20 ft. by 8 ft., carries five containers in transverse channels. A screw-type, hold-down device raises and clamps each container in its two channels for rail movement, removing weight from the container's four casters which are used for rolling it on and off the car and for moving it on station platforms. The rack-cradle loaded with five containers can be end-loaded on the car from a flat-bed truck, utilizing the components of the Clejan system developed for handling 20-ft. and 40-ft. containers. Hinged extensions of the transverse channels serve as container stops when raised, and,



Platform truck is alined perpendicular to general American car and channel bridges are lowered to mesh with corresponding channels on rack-cradle.

Roller mechanism on Pullman-Standard car is elevated with chain from adjustable-height platform truck which also has rollers on its deck.



Locking cones in locked position secure the Trailmobile container on the car; rollers are raised to move container on and off the car.

when lowered, act as bridges to the platform truck or to a platform. It is possible for the car to carry one or more rack-cradles and other types of containers simultaneously.

The 212-cu. ft. Fruehauf magnesium container has a width of 7 ft. 10 3/8 in., a height of 8 ft. 2 3/4 in., and a length of 3 ft. 8 3/4 in. It has a light weight of 496 lb. and a 4 000-lb. capacity. There are 41-in. by 83-in. double-swing doors in one side and one end, fitted with piano-type hinges and rubber gaskets. The container has a magnesium 0.125-in. tread-plate floor. Sides are 0.156-in. magnesium. Lifting rings, fork-lift plates, and tow bars are standard.

The 50-ton capacity, 87-ft. skeleton-type Pullman-Standard car, equipped for passenger service, has a stationary container rack consisting of two I-beams running the length of the car atop the center sill. Top of the center sill is 41 1/2 in. above the rail. The two 6-in. I-beams are 39 1/2 in. apart. Steel cones with wing tips placed at 5-ft. intervals on these beams secure the containers. After disengaging a safety latch, a lever is shifted to unlock all the hold-down cones on one beam simultaneously. The process is then repeated to disengage cones along the opposite beam.

Transfer of the 5-ft. containers to and from the REA hydraulic variable-height platform truck is accomplished by the raising steel rollers on the P-S car and winching the container on to similar rollers on the edges of the platform truck. After roller wheels on the car are raised by chains, which are attached to their elevating mechanism from the platform truck, a link-chain pulley system makes it possible to move containers.

This « all-container » car is built not only to handle the smallest 5-ft. containers, but can carry others in 10-ft. modular lengths up to 40 ft. A variety of different sizes can be carried simultaneously.

The Trailmobile containers are made of 16-gage steel with exposed integral posts. They are 4 ft. 10 1/4 in. long, 8 ft. wide, and 8 ft. high. Each container weighs 1 450 lb. and has a payload limit of 4 550 lb. In the two ends and one side are 51-in. by 87-in. door openings, each having rubber-sealed, piano-hinged, double-swing doors. Floors are 3/4-in. oak.

Light weight of the P-S car is 45 900 lb., and sixteen loaded containers weigh 96 000 lb. Tests at the P-S research laboratory in Hammond, Ind., have shown that the cone-type hold-downs on an uncushioned cradle comprise « an arrangement completely adequate for passenger-train service ».

[625 .174 (52)]

Rationalization of snow removal by the JNR,

by Kojiro NEGORO

(From the *Japanese Railway Engineering*, March 1961.)

1. Snowfall in Japan.

The so-called « high in west, low in east » distribution of atmospheric pressure dominates the land of Japan in winter, as high atmospheric pressure is produced to the north-west in the continent, i.e. Siberia and Manchuria, and conversely the oceanic atmospheric pressure is relatively low, with the result that the north-west monsoon become heavy.

This monsoon brings a number of snowfalls to the northern part of Japan, particularly on the coast of the Japan Sea. Therefore, as much as 40 % of Japan is covered with snow in winter, and it is not rare for the snow cover to last for 60 days and the maximum snow depth to reach 150 cm. Snowfalls, when accompanied by a heavy monsoon often turn into snowstorms, and the precipitation often exceeds 50 cm. Snowfall conditions in large cities in the snowy area and the average snowfall in February is shown in figure 1.

2. Effect of snow on JNR.

Low temperature in itself has a deleterious effect on railways in some way or another, and snow can do far greater damage. Especially, snow in Japan is mostly damp snow which is not so low in temperature and has a large water content and hence a large specific gravity, so much so that it is hard to dispose of and its adverse effects become heavier. For this reason about 8 000 km out of the JNR's total working lines of 20 000 km, are influenced by snow. To cope with this, the JNR holds various kinds of fixed installations, rolling stock and machinery to fight snow and they amount to a considerable number. The total loss is tremendous when we take account of expenses for the operation of snow removing trains, the labor cost of snow removal, the increase in annual expenses for temporary work to prevent snow damage, the increase in power costs resulting from increased running resistance by trains, the decrease in revenue resulting from reduction of service, expenses for measures entailed by accidents due to snow, and so on. In spite of all efforts, train accidents, including « bad delays », amount to between 300 to 500 cases annually, and the total time of delay of train S = trains reaches 1 600 hours.

The types and numbers of assests the JNR holds in order to tackle snow are tabulated below.

	Quantity	Length
Snow removing wagons.	291*	—
Protective belt of trees	17 000 ha	2 000 km
Snow sheds	243	14.8 km
Snow walls and snow fences	1 271	86.2 km
Drain ditches for removing snow. . .	359	218.4 km

(*) Note. — The 291 wagons are broken down as follows:

Russel snow plows . . .	193...	for single tracks
Russel snow plows . . .	37...	for double tracks
Rotary snow plows . . .	18	
Jordan snow plows . . .	23	
Mackley's snow plows .	18	
Snow-loader plows . . .	1	
Diesel powered rotary snow plows	1...	test manufactured in 1960

The principal items of JNR's annual expenditure earmarked for snow are as follows:

	Unit	Quantity	Expenses (million yen)
Operation of snow removing trains	Train-km	250 000 -420 000	230-380
Labor for snow removing	Man-day	380 000 -820,000	220-460
Temporary installations	Linear km	150-170	40- 50
Maintenance of snow removing facilities			230-260

3. Problems with regard to present measures against snow.

The track between stations is protected by a belt of trees (photo 1) against snowstorms and snowdrifts caused by the monsoon conditions and especially dangerous sections are provided with snow fences (photo 2) or snow sheds. There are few problems with regard to ordinary snowfalls, since snow plows can dispose of snow at any required rate. The things which must be done are to improve the performance capacity of snow plows so as to suit varying conditions as well as to reduce the operational o = costs.

On the other hand, the suspension or showing down of yard functions, parti-

cularly those of big marshalling yards, would badly affect train operation. One failure leads to another and the effect is liable to become a chain-reaction. Therefore, the removal of snow in yards is especially important. But it is hard to install appropriate snow protection devices in yards because many tracks are spread over a wide area. Furthermore, the disposal of snow is hampered by turnout, signalling installations, electric poles and standing cars, and there is but limited space to pile the snow removed from the plows and other snow removing equipment is limited. For this reason, in large yards, much of the work depends on man power, such as the removal of snow taken from tracks and that piled in between and the removing of snow at turnouts. This is a major factor adding to the cost of snow removal. Therefore, the problem is how to facilitate the carrying away of snow, and improve snow removing equipment for turnouts so as to be highly effective even in a heavy snowstorm. To facilitate the carrying away of snow, efforts are being made to develop loading equipment, snow carrying wagons and unloading equipment suitable for conditions pertaining in a large yard. However, the more fundamental measure is to install a « ditch for the removal of snow », as hitherto practised in the JNR, i.e. a channel of a sufficient capacity and current speed installed between tracks, whereby the snow removed by a snow plow is to be automatically carried away by water. Efforts are now being directed to wider application of this technique within practical limits (photo 3).

Fig. 1

Average of snow depth in Feb.

Name of cities	Minimum temperature	Period of snow cover	Maximum snow depth	Total precipitation of snow
Kanazawa	− 4°C	57 days	80 cm	205 cm
Niigata	− 6	60	90	235
Nagano	−12	64	40	115
Akita	− 12	69	55	185
Hakodate	12	84	60	425
Sapporo	−15	97	130	725
Asahigawa	−24	102	85	525

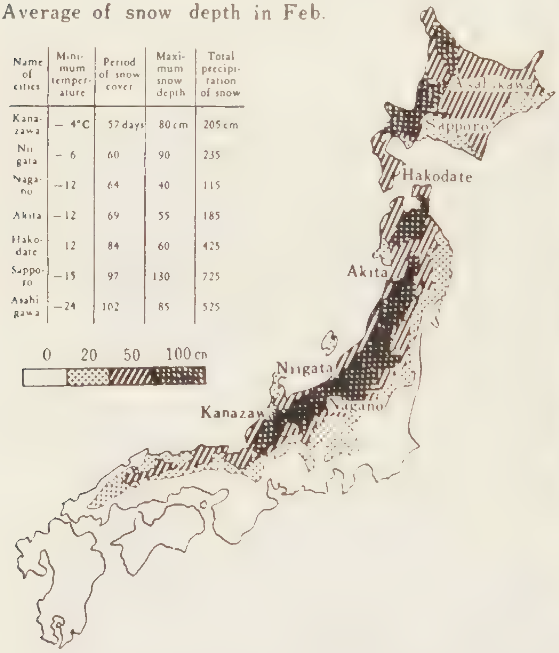


Photo 1 Protective belt of trees against snow

Photo 2 Snow fence

The most widely used snow removing device at turnouts is the point heater system which, already in long use is an electric heater placed inside the tie plates lying under the tongue rail. However, it is not always effective in heavy snow-

storms. Therefore, use of compressed air is being studied as to its economic aspects and the details of construction. Also, the use of paint to minimize the sticking of snow, the protection of signals against sticking snow and the removal of snow are problems still to be solved.

Photo 3. — Ditch for removing snow.

4. Addition of snow removal ditch.

The installation of a drain for the removal of snow is, as stated above, a fundamental means of facilitating snow planning for a snow removal ditch, it is necessary to solve the technical problem of whether a water source is available to ensure the necessary supply of water in winter and how to design a discharge drain free from such troubles as freezing. In addition there is the economic problem of whether there is such a favorable economic effect that the high capital cost due to the initial investment will be returned. The quantity of water required in a snow removal ditch is 10-30 ton/min, as a 50 to 100 cm wide, 30 cm deeper ditch should let water run at a speed of 50 cm/sec or more. To this end, the capacity of the water source should be twice or three times that quantity, considering fluctuations in the amount of water used. The water source can be river water, sea water or well water pumped up or river water naturally flowing in. Whether the water source is suitable or not is the key factor in designing a snow removal ditch, because the distance to the water source is limited by economic considerations.

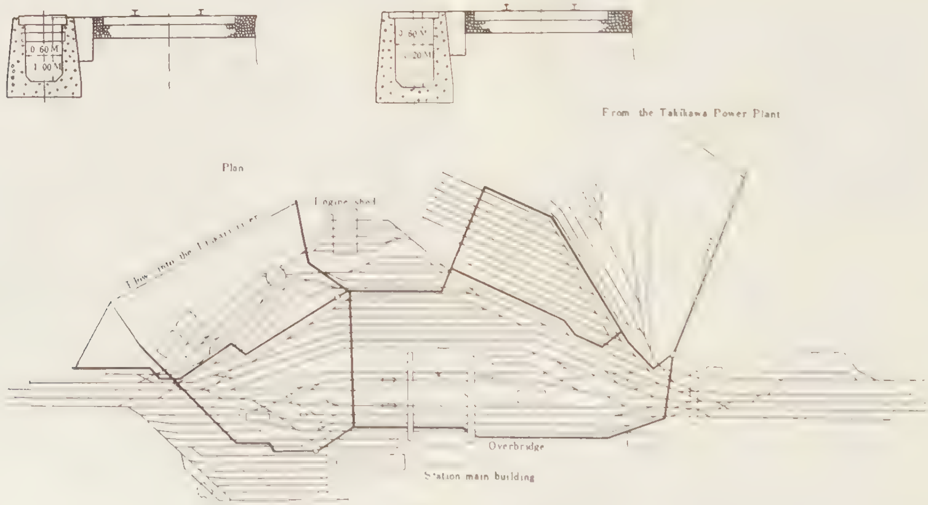
The JNR has such drains for snow removal at 359 places and they total 218 km in length. The existing installations are, for the most part, about 1 000 m long, being in medium or minor yards which have a suitable water source nearby. At present the policy is to install them one by one even in a big yard in a snowy area, whenever various conditions, including water source, are regarded as favorable. A few examples of existing facilities in big yards are outlined as follows :

Photo 4. — Snow removing wagons, Rotary-type.

	Nagaoka marshalling yard	Aomori marshalling yard
Total length of trackage	33 km	79 km
Water source: Kind Quantity	 River water pumped up 25 m³/min	 Sea water pumped up 40 m³/min
Channel from water source	Pressure-conveyance under ground ∅ 60 cm × 440 m	Pressure-conveyance under ground ∅ 80 cm × 145 m
Ditch for snow removal:		
Total length	7 690 m	8 517 m
Cross section	80 cm wide 60-180 cm deep	70-100 cm wide 55-240 cm deep
Grade	1.1-1.6 ‰	1.5-2.0 ‰
Planned current speed	96 cm/sec	70-100 cm/sec
Planned water depth	25 cm	29-35 cm

There is a somewhat unusual project planned recently, in which the cooling water discharged from a steam power plant is to be made use of. It is the snow removal ditch under construction in the Takikawa yard. An outline of the project is given in figure 2.

Located in the central part of Hokkaido, Takikawa is a medium sized junction station, where the removal of snow every winter calls for the operation of snow plow over 1 200 km and a total of 1 900 snow carrying wagons, as well as an average of 7 000 man-days of labor. A thermal power plant of output capacity of 22 500 kW was constructed in 1959 about 3 km away from the station. This steam power plant constantly discharges abundant cooling water of a relatively high temperature. The snow removal ditch for the station is to utilize the discharged water as its water source. The work is now in progress. Some of the cooling water discharged from the steam power plant at 18° C is to be pumped up from the tail race and led to the snow removal ditch, 60 cm wide, 60-190 cm deep, graded 1.8 ‰ and covering a total length of 2 570 m. Snow removed from the tracks



Standard Section of drain for snow removing

Fig. 2

by a snow plow is to be thrown into the ditch to be carried away.

One of the benefits of using the cooling water from a steam power plant as a water source is that the water temperature is so high that it melts snow effectively and therefore the channel will never be stopped up or frozen, no matter how much snow may be thrown into it. It is anticipated that the new snow removal ditch will cut annual snow removal expenses by about 7 million yen.

The technological data of the project are summarized as follows :

Water pump... :
110 kVA lift head, 22 m; working pumping capacity, 17.4 m^3/sec.

Waterway... :
Pressure hume pipe, diam. 50 cm; total length, 2 630 m; depth below ground level, 1.2 m; current speed in pipe, 1.5 m/sec.

Snow removal ditch... :
Length, 2 570 m; width, 0.6 m; depth, 0.6-1.9 m; width, 0.6-1.9 m; grade, 1.8 ‰; planned water depth, 0.3 m; planned current speed, 0.83 m/sec.

Total cost of work... :
76 million yen.

5. Improvement of snow removing wagons.

At present, various types (photos 5 and 7) of snow removing wagons are in active service, including the plow type and rotary type (photos 4 and 6). On some sections, it is sometimes un-economical, in the light state of snow, to use a train hauling powered vehicle, because its horse-power is too large. To remedy the state of matters, a

Photo 5. — Snow removing wagons Rotary-type.

Photo 6. — Snow removing wagon, Russel-type.

Diesel driven snow removing wagon of the self-propelled type has been tentatively manufactured in order to cut fuel costs and personnel expenses. A small wagon of the track motor car type capable of self-propulsion (photos 8 and 9), which is to be made use of for track maintenance service in summer, has also been manufactured on a trial basis so that its employment rate may be raised. Both of these newly-developed snow removing wagons are showing excellent results.

Photo 7. — Snow removing wagon, Jordan-type.

Photo 9. — Snow removing motor-car.

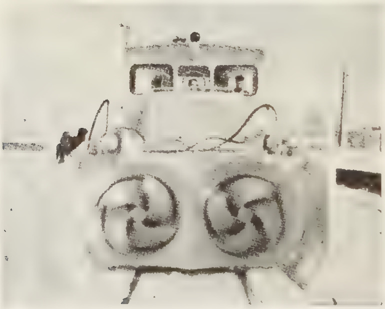


Photo 8. — Snow removing dieselcar, Beilhack.

Photo 10. — Side dumping tractor shovel engine.

[625 .13 (73)]

Big concrete pipe for school crossing is jacked in place

(*Railway Track and Structures*, April, 1961.)

At Columbus, Ohio, it was found necessary to provide a means of permitting junior high school students to cross the New York Central main tracks safely. The solution adopted was to install a pedestrian underpass consisting of 80-in. by 80-in. precast concrete pipe with ramp approaches.

— When it was building a new junior high school, the City of Columbus, Ohio, found that a large number of teenagers resided on the other side of the New York Central main tracks. It was confronted with the problem of getting these students back and forth across the tracks safely.

Since the tracks were approximately at ground level, a pedestrian crossing could be built overhead or beneath the tracks.

Completed underpass invites use by students going to and from new junior high school (background) at Columbus, Ohio, by making it easier for them to go under tracks than to walk over them. Landscaping adds to attractive appearance.

It was reasoned that the youngsters would refrain from walking directly over the tracks and would be inclined to use a walkway if steps were eliminated. Accordingly, it was decided to install a large pipe beneath the tracks with easy sloping ramps at each end. For this purpose the railroad selected 80-in. by 80-in. precast concrete flat-base pipe furnished by the American-Marietta Company. To preclude interference with rail traffic, it was further decided to install the pipe by using the jacking method.

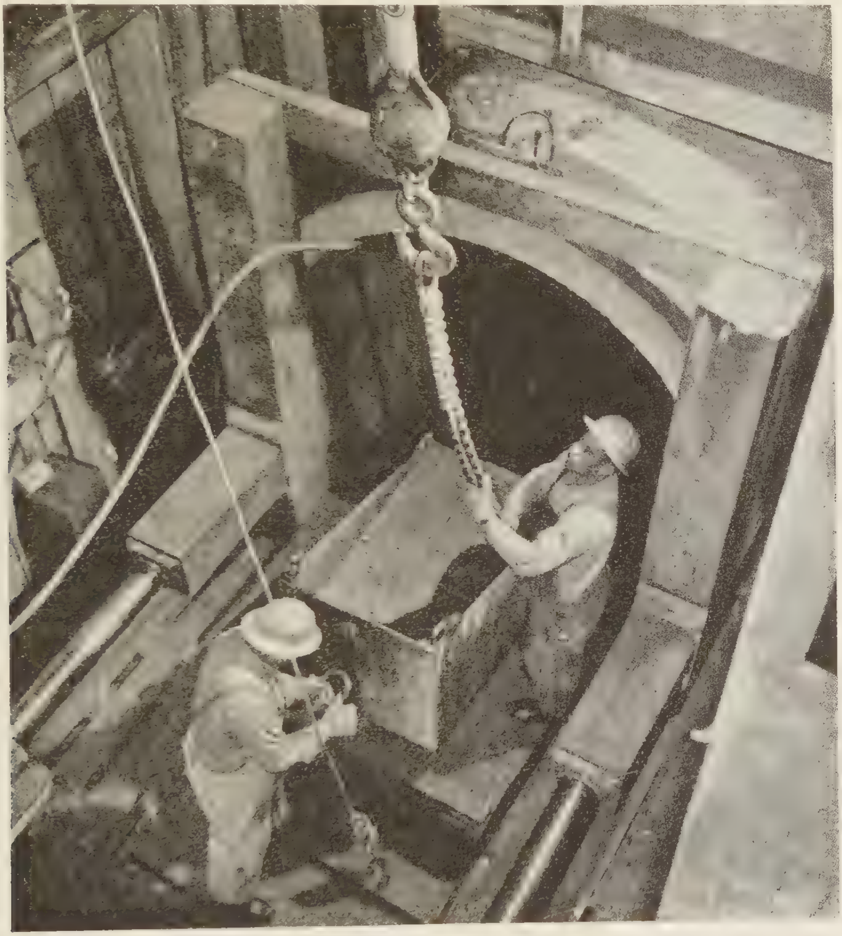
Inside joints were sealed with non-shrink mortar for insuring watertight construction. Floor of underpass was paved.

As a preliminary step the contractor dug a jacking pit, approximately 13 ft. wide by 17 ft. long by 15 ft. deep to one side of the right of way, and shored it. In it he constructed his jacking frame at the desired level and installed two 200-ton hydraulic jacks.

The pipe sections were lowered into the pit by a crane. Each section was four feet long and weighed 11 700 lb. As the jacking work progressed three men removed the earth from ahead of the pipe, using an air-powered spade and hand shovels to dig out the hard clay. This material was loaded into a three-wheeled muck buggy which was pushed from the pipe head to the jacking pit where it was lifted out and unloaded by the crane. Lights were strung overhead as the digging proceeded so the work could be progressed on a 24-h basis.

The jacking thrust was transferred to the pipe by a special 18-in. section of the same-size pipe. The maximum thrust needed was 360 tons, or 180 tons on each jack. Manila rope was used at the joints to help distribute the jacking thrust from one section to the next. The work proceeded at an approximate rate of 4 in. per hour, or 8 ft. in 24 h. The desired alinement was maintained by regulating the positions of the jacks on the pipe.

After the pipe had been jacked about 108 ft., an excavation was made at the far end and the remainder of the pipe was laid in an open cut. A joint mastic was used to fill the outside joints. The inside joints were sealed with a non-shrink mortar to provide water-tight joints. The base of the tunnel was paved.



Jacking power was provided by two 200-ton hydraulic jacks. Thrust was transferred to 80-in. by 80-in. concrete pipe sections by a special 18-in. section.

To give access to the pipe open cuts were excavated at each end. Concrete headwalls and sloping ramps with concrete retaining walls were constructed. Catch basins were built at each end of the tunnel portion and sump pumps were used to take care of the drainage until a new storm sewer was laid, after which the catch basins were connected with the sewer. Permanent light fixtures were installed. The areas on each side were sodded and landscaped. The result was an attractive underpass which was completed in time for the formal opening of the school.

[656 .212 .5]

Closing-up of groups of wagons in sorting sidings,

by N.I. Fjedotow,

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Translated into German by Dipl. Eng. G. Opitz.

(*Deutsche Eisenbahntechnik*, No. 12, 1960.)

1. Introduction.

During humping, rakes of wagons with different rolling resistance follow each other over the hump. The distances covered by individual rakes of wagons will therefore differ and the rakes will, in the sidings, be separated by sections of unoccupied track (« gaps »). To eliminate these gaps, the wagons are « closed up » by traction equipment which may work on the tracks, or between them.

Among the traction equipment moving on the tracks are all varieties of shunting locomotives; among the traction equipment working between the tracks are cable haulage devices, tractors powered by electric batteries and working on narrow-gauge tracks placed between the sidings, and road tractors working on special carriageways between the sidings.

Experience gained with cable haulage devices at Munich East Marshalling Yard, and with battery worked tractors at Magdeburg-Rothensee, has shown that, from an economic and technical point of view, such devices cannot be regarded as suitable for the closing-up of wagons in sorting sidings. In practice, the closing-up operations in the sorting sidings of hump yards are mainly carried out by shunting locomotives. A few yards make use of tractors.

In current practice, the amount of work required for the closing-up of the wagons is calculated approximately, but is often not related to the actual provision of shunting locomotives, etc. Yet a more precise calculation of the time required for the closing-up of wagons is a prerequisite to the solution of a number of problems, both in existing and in planned hump yards.

In this connection, the attempt is made, in the following, to determine the time required for the closing-up of wagons by locomotives working on the hump side, by locomotives working on the train formation side, and by tractors.

For the calculation of the required closing-up time, it is first of all necessary to determine the mean number of wagons which must have been collected in the sorting siding before a closing-up operation is called for. The length of this group of wagons (« length of group to be closed up ») depends not only on the nature of the flow of wagons but also on the way in which the humped wagons are braked (complete or incomplete distance braking).

2. Length of the group of wagons to be closed up in the case of complete distance braking.

With complete distance braking, all the humped wagons are braked in such a way that they collide, at an acceptable speed, with the wagons already standing in the sidings. If, under these conditions, all the humped wagons would have the same rolling resistance, the length of the group of wagons to be closed up would be equal to the distance covered by un-braked humped wagons. In fact, however, the rakes of humped wagons have different rolling resistances. In the circumstances, the length of the group of wagons to be closed up

depends not only on the distance covered by the rakes with different rolling resistances, but also on their sequence.

The appearance of rakes of wagons with a given rolling resistance, and thus with a given distance coverage, is a random occurrence. For the same reason, the number of rakes of wagons requiring a closing-up operation in the siding is likewise a random variable. The length of the group of wagons to be closed up, being the mean of the random values, can be calculated with the aid of the laws of probability. The nature of the flow of wagons passing over the hump can, as far as rolling characteristics are concerned, by characterized by classifying the rolling resistances of the humped rakes.

In examining the relationship between the length of the group of wagons to be closed up and the nature of the flow of wagons, let us first consider the classification of the rolling resistances, as set out in Table 1.

where :

l_1, l_2, l_3 signify the distances in the siding covered by the rakes of wagons with the rolling resistances w_1, w_2, w_3, respectively, and

l_{Ag} the mean length of the rakes.

For the classification of the rolling resistances of the rakes of humped wagons, set out in Table 1, we assume $n_2 = 3$ and $n_3 = 4$. The probability that the first rake of wagons entering the sorting siding from the hump has a rolling resistance w_1 so that the length of the group of wagons to be closed up becomes l_1 (number of rakes) :

$$n_1 = \frac{l_1}{l_{Ag}},$$

is α_1 as the following rakes of wagons entering the same siding will run up closely on this section provided that the distance brakes are correctly applied.

TABLE 1. — **Classification of the rolling resistances of the rakes of humped wagons.**

Rolling resistances, due to friction and wind, in kg/t	w_1	w_2	w_3	$w_1 > w_2 > w_3$
Probabilities of these rolling resistances occurring .	α_1	α_2	α_3	$\alpha_1 + \alpha_2 + \alpha_3 = 1$
Rolling distances	l_1	l_2	l_3	$l_1 < l_2 < l_3$

The numbers of rakes of humped wagons which can be accommodated on the section of the siding between the points clearance mark and the point at which the rake with the rolling resistance w_1 has stopped, and on the sections between the points reached by the rakes with the rolling resistances w_1, w_2, w_3 respectively, can be calculated from the following formulas :

$$n_1 = \frac{l_1}{l_{Ag}} \quad (1a) \qquad n_2 = \frac{l_2 - l_1}{l_{Ag}} \quad (1b)$$

$$n_3 = \frac{l_3 - l_2}{l_{Ag}} \quad (1c)$$

The probability that the group to be closed up contains $(n_1 + 1)$ rakes is equal to the probability of a rake with the rolling resistance w_2 or w_3 being followed by a rake with the highest rolling resistance w_1, viz.

$$p(n_1 + 1) = \alpha_1 (1 - \alpha_1) \qquad (2)$$

The probability that the group to be closed up contains $(n_1 + 2)$ rakes correspondingly amounts to

$$p(n_1 + 2) = \alpha_1 (1 - \alpha_1)^2 \qquad (3)$$

Table 2 shows the possible variants in the distribution of the rakes of humped wagons,

and the probabilities of these variants, assuming $(n_1 + 3)$ rakes of wagons within the group. The distribution of the rakes shown in the third line of Table 2 is shown schematically in figure 1 (where, for simplicity's sake, the rakes are shown as single wagons).

To determine the probability of $(n_1 + 3)$ rakes being contained in the group to be closed up, the probabilities of the possible variants must be added, i.e.

$$p(n_1 + 3) = p_1 + p_2 + p_3 + \dots + p_8 \qquad (4a)$$

where :

$p_1, p_2, p_3 \dots p_8$ signify the probabilities of the distributions of the rakes shown, respectively, in lines 1, 2, 3, ... 8 of the Table.

If the values for p_1, p_2, $p_3 \dots p_8$ are substituted in (4*a*), we obtain

$$p(n_1 + 3) = (1 - \alpha_1)^3 \cdot (\alpha_1 + \alpha_2) \qquad (4)$$

If the section $(l_1 - l_2)$ accommodates not three but n_2 rakes of wagons, the probability of $(n_1 + n_2)$ rakes being contained in the group to be closed up amounts to :

$$p(n_1 + n_2) = (1 - \alpha_1)^{n_2} \cdot (\alpha_1 + \alpha_2), \qquad (5)$$

The probability of $(n_1 + n_2 + 1)$ rakes being contained in the group to be closed up amounts to

$$p(n_1 + n_2 + 1)$$

$$= (1 - \alpha_1)^{n_2} \cdot (\alpha_1 + \alpha_2)\,[1 - (\alpha_1 + \alpha_2)]; \qquad 5a)$$

TABLE 2. — **Variants in the distribution of the rakes of humped wagons.**

No.	Number of rakes of humped wagons having the rolling resistance		Stopping point of the rakes							Probability of the distribution of the rakes of humped wagons in the given sequence
			Section $l_1 - l_2$			Section $l_2 - l_3$				
	w_2	w_3	1	2	3	4	5	6	7	
1	0	3	—	—	—	—	w_3	w_3	w_3	$\alpha \cdot \alpha_3^3$
2	1	2	—	—	w_2	—	—	w_3	w_3	$\alpha_1 \cdot \alpha_2 \cdot \alpha_3^2$
3	1	2	—	w_3	w_2	—	—	—	w_3	$\alpha_1 \cdot \alpha_2 \cdot \alpha_3^2$
4	1	2	w_3	w_3	w_2	—	—	—	—	$\alpha_2 \cdot \alpha_3^2$
5	2	1	—	w_2	w_2	—	—	—	w_3	$\alpha_1 \cdot \alpha_2^2 \cdot \alpha_3$
6	2	1	w_3	w_2	w_2	—	—	—	—	$\alpha_2^2 \cdot \alpha_3$
7	2	1	w_2	w_3	w_2	—	—	—	—	$\alpha_2^2 \cdot \alpha_3$
8	3	0	w_2	w_2	w_2	—	—	—	—	α_2^3
9	$p(n_1 + 3) = \Sigma p = (1 - \alpha_1)^3 \cdot (\alpha_1 + \alpha_2)$									

and correspondingly for $(n_1 + n_2 + 2)$:

$$p(n_1 + n_2 + 2)$$

$$= (1 - \alpha_1)^{n_2} \cdot (\alpha_1 + \alpha_2) [1 - (\alpha_1 + \alpha_2)]^2; \quad (5b)$$

The probabilities of any other numbers of rakes being contained in the group of wagons to be closed up can be determined in a similar way.

If :

$$1 - \alpha_1 = g_1$$

$$1 - (\alpha_1 + \alpha_2) = g_2$$

$$1 - (\alpha_1 + \alpha_2 + \alpha_3) = g_3$$

$$\cdots\cdots\cdots\cdots$$

$$1 - \sum_1^K \alpha = g_K \quad (6)$$

accommodated in the corresponding sections $(l_1 - l_2)$, $(l_2 - l_3)$, $(l_{K-1} - l_K)$, and

i is a positive number which can be determined from equation (7*a*).

The mathematical expectation value for the number of rakes of humped wagons in the group to be closed up amounts to :

$$\text{M. E. } (n)$$

$$= n_1 \cdot p(n_1) + (n_1 + 1) \cdot p(n_1 + 1) + (n_1 + 2)$$

$$p(n_1 + 2) + \ldots + n \cdot p(n) + \ldots$$

$$+ \sum_1^r n_j \cdot p[\sum_1^r n_j]; \quad (8a)$$

If the corresponding values for $p(n_1)$, $p(n_1 + 1)$, $p(n_1 + 2)$, $p(n)$, determined with the aid of formula (7), are substituted in (8*a*),

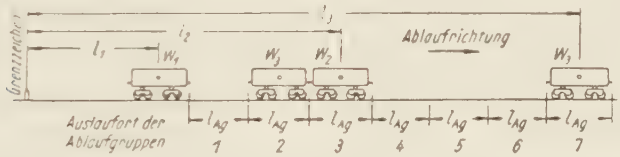

Fig. 1. — Variant of the distribution of rakes of humped wagons.

N. B. — Grenzzeichen = clearance mark. — Ablaufrichtung = direction of humping. — Auslaufort der Ablaufgruppen = points at which the rakes of humped wagons come to rest.

The probability of the group to be closed up containing n rakes of humped wagons amounts to :

$$p(n) = g_1{}^{n_2} \cdot g_2{}^{n_3} \cdot g_3{}^{n_4} \ldots g^{n_K}{}_{K-1} (1 - g_K) g^i{}_K \quad (7)$$

The values for K and i follow from the following conditions :

$$n = \sum_1^K n_j + i; \quad (7a)$$

$$n_{K+1} > i \geqslant 0 \quad (7b)$$

where :

$n_1, n_2, \ldots n_K$ signify the numbers of rakes of humped wagons which can be

one obtains, for the mathematical expectation,

$$\text{M. E. } (n)$$

$$= n_1 (1 - g_1) + (n_1 + 1) g_1 (1 - g_1) + (n_1 + 2)$$

$$(1 - g_1) \cdot g^2{}_1 + \ldots + (n_1 + n_2 - 1)(1 - g_1)$$

$$g_1{}^{(n_2 - 1)} + (n_1 + n_2) g_1{}^{n_2} (1 - g_2)$$

$$+ \ldots + (n_1 + n_2 + n_3 - 1) \cdot g_1{}^{n_2} \cdot g_2{}^{(n_3 - 1)}$$

$$(1 - g_2) + (n_1 + n_2 + n_3) g_1{}^{n_2} \cdot g_2{}^{n_3} (1 - g_3)$$

$$+ \ldots g_1{}^{n_2} \cdot g_2{}^{n_3} \cdot g_3{}^{n_4} \cdot \ldots \cdot g_{r-1}^{n_r} \sum_1^r n_j \quad (8b)$$

The right-hand side of this equation can be resolved into a number of geometrical progressions whose sum can be determined and yields :

$$\text{M. E. }(n) = n_1 + \frac{g_1 - g_1^{n_2}}{1 - g_1} + \sum_{i=1}^{i=r-2} g_1^{n_2}\, g_2^{n_3}\, g_3^{n_4} \ldots \cdot g_i^{n_{i+1}} \frac{1 - g_{i+1}^{n_{i+2}}}{1 - g_{i+1}} \quad (8)$$

The length of the group of wagons to be closed up amounts to :

$$L_{Bg} = l_1 + l_{Ag} \frac{g_1 - g_1^{n_2}}{1 - g_1} + l_{Ag} \sum_{i=1}^{i=r-2} g_1^{n_2} \cdot g_2^{n_3} \cdot g_3^{n_4} \cdot \ldots \cdot g_i^{n_{i+1}} \frac{1 - g_{i+1}^{n_{i+2}}}{1 - g_{i+1}} \quad (9)$$

where :

r is the number of intervals chosen for the classification of the rolling resistance (see Table).

To facilitate the understanding of the sequence of calculation, it is now proposed to determine the length of the group of wagons to be closed up for the following classification of the rolling resistances (Table 3).

To determine L_{Bg}, it is first of all necessary to determine the values of g, l and n. The values of g are determined by formula (6) and tabulated in Table 4.

The distances covered by the rakes of humped wagons in the sorting siding beyond the points clearance mark are determined with the aid of the following formula :

$$l = \frac{H + h_0 - h_K - L \cdot w \cdot 10^{-3}}{(w - i_S) \cdot 10^{-3}} \quad (10)$$

where :

- H = signifies the height of the hump, i.e. the difference in level between the top of the hump and the last of the distribution points, in metres;
- h_0 = the height equivalent to the energy imparted by the humping speed, in metres;
- h_K = the height equivalent to the kinetic energy required for overcoming the additional rolling resistance in points and curves, in metres;
- L = the distance between the top of the hump and the points clearance mark beyond the farthest distribution point, in metres;
- i_S = the gradient of the sorting siding, in pars pro mille;
- w = the rolling resistance of the rake of wagons, in kg/ton.

TABLE 3.

Rolling resistance in kg/t	10to11	9 to 10	8 to 9	7 to 8	6 to 7	5 to 6	4 to 5	3 to 4	2 to 3	1.5 to2
Probability of the occurrence of these rolling resistances	0.041	0.037	0.053	0.081	0.130	0.149	0.168	0.157	0.119	0.065

TABLE 4.

Index	1	2	3	4	5	6	7	8	9	10
Rolling resistance in kg/t	10to11	9 to 10	8 to 9	7 to 8	6 to 7	5 to 6	4 to 5	3 to 4	2 to 3	1.5 to2
Probability of the occurrence of these rolling resistances	0.041	0.037	0.053	0.081	0.130	0.149	0.168	0.157	0.119	0.065
g	0.959	0.922	0.869	0.788	0.658	0.509	0.341	0.184	0.065	0
l (m).	35	72	122	179	256	368	525	660	910	950
n	1.59	1.68	2.27	2.58	3.50	5.10	7.15	6.15	11.40	1.82

If the gradient of the sorting sidings is opposed to that of the hump, the distances covered by the rakes of humped wagons on this opposing slope can be determined with the aid of the following formula :

$$l = \frac{\mathrm{H} + h_0 - h_\mathrm{K} + (i_\mathrm{S} + i_\mathrm{SA}) l_s \cdot 10^{-3} - \mathrm{L} \cdot w \cdot 10^{-3}}{(w - i_\mathrm{SA}) \cdot 10^{-3}}$$

where :

i_SA = signifies the magnitude of the opposing gradient, in pars pro mille;

l_s = the length of section of track having the gradient i_S.

By way of example the following numerical values may be assumed :

$\mathrm{H} = 4.05$ m; $h_0 = 0.1$ m; $h_\mathrm{K} = 0.75$ m;

$\mathrm{L} = 290$ m; $i_\mathrm{S} = 0.6$ ‰; $l_s = 500$ m; $i_\mathrm{SA} = 1.7$ ‰.

The mean distances covered by the rakes of wagons with different rolling resistances are tabulated in Table 4.

The maximum distance, 950 m, indicates the useful length of the sorting siding.

The numbers of rakes of wagons, n_1, n_2, n_3 ... have been determined for $l_{\mathrm{A}g} = 22$ m with the aid of formulas (1*a*) to (1*c*), and are likewise shown in Table 4. For the given classification of the rolling resistances, formula (9) assumes the following form :

$$\mathrm{L}_{\mathrm{B}g} = l_1 + l_{\mathrm{A}g} \frac{g_1 - g_1^{n_2}}{1 - g_1}$$

$$+ l_{\mathrm{A}g} \left[g_1^{n_2} \frac{1 - g_2^{n_3}}{1 - g_2} + g_1^{n_2} \cdot g_2^{n_3} \frac{1 - g_3^{n_4}}{1 - g_3} + \ldots + g_1^{n_2} \cdot g_2^{n_3} \cdot g_3^{n_4} \cdot \ldots \cdot g_7^{n_8} \cdot g_8^{n_9} \frac{1 - g_9^{n_{10}}}{1 - g_9} \right]$$

If the corresponding values from Table 4 are substituted in this formula, one obtains $\mathrm{L}_{\mathrm{B}g}$ = approx. 180 m.

3. Length of the group of wagons to be closed up in the case of incomplete distance braking.

With complete distance braking, the braking of all the rakes of humped wagons is controlled in such a way that they cover the greatest possible distance obtainable with their rolling resistance and that, at the same time, the sorting sidings are fully utilized. Under the practical conditions prevailing at hump yards, such braking of the rakes of humped wagons will, however, not always be possible or even desirable. For instance, if a free runner that has come to a standstill at the beginning of the sorting siding is followed by a bad runner, which is humped without brake application (if the wagons in the siding concerned are at a distance exceeding that covered by the bad runner), the interval between the humped rakes of wagons at the top of the hump will be considerably increased, and the humping rate will be reduced.

In order to minimize the interval between the rakes, it is in this case possible to apply the brakes to the bad runner as well, which will however, reduce the distance covered by it.

In such circumstances, complete distance braking will only be applied to some of the rakes of humped wagons, whilst the distances covered by the other rakes of wagons, which must be braked merely to ensure the absolutely necessary intervals between the rakes, are considerably reduced. It may also be necessary to accept a restriction on complete distance braking if the rakes are distributed over points situated beyond the last retarders, and if the following conditions are encountered :

a) The first rake of humped wagons covers (in accordance with the occupation of the sorting sidings) such a distance l'_E that the distance covered by the second rake, l''_E, must be reduced, whilst

b) The second rake should, in accordance with the occupation of the sidings, cover a distance exceeding l''_E.

The probability of the first condition

being encountered amounts to l'_E/l', and that of the second condition being encountered to $\frac{l'' - l''_E}{l''} = 1 - \frac{l''_E}{l''}$,

where :

l', l'' signify the maximum distance which could be covered by the first and second rake, respectively, taking into account the given rolling resistances and the height of the hump.

The probability of the running distance of the second rake having to be restricted if its rolling resistance is w_1 and that of the first rake also w_1 amounts to :

$$P_{UB}(w_1;w_1) = z\,\frac{l'_{E-1}}{l'_1}\left(1 - \frac{l''_{E-1}}{l''_1}\right)\alpha_1 \cdot \alpha_1 \qquad \ldots\ldots \quad (12a)$$

Correspondingly, if the second rake has a rolling resistance w_1 but the first rake a rolling resistance w_2 the probability of restriction works out at :

$$P_{UB}(w_K;w_1) = z\,\frac{l'_{E-2}}{l'_2}\left(1 - \frac{l''_{E-1}}{l''_1}\right)\alpha_1 \cdot \alpha_2 \qquad \ldots\ldots \quad (12b)$$

More generally, if the second rake has a rolling resistance w_1 and the first rake a rolling resistance w_K, the probability of the distance covered by the second rake having to be reduced amounts to :

$$P_{UB}(w;\ w_1) = z\,\frac{l'_{E-K}}{l'_K}\left(1 - \frac{l''_{E-1}}{l''_1}\right)\alpha_1 \cdot \alpha_K \qquad \ldots\ldots \quad (12)$$

where :

z signifies the probability of the two rakes being separated by the points concerned, and

$\alpha_1, \alpha_2 \ldots \alpha_K$ the probabilities of the occurrence of rakes of humped wagons with the rolling resistances w_1, w_2, w_K, respectively.

The probability of the distance covered by the second rake, with a rolling resistance of w_1, having to be reduced because of the rolling resistances of the first rakes ranging from w_1 to w_K, is equal to the sum of the probabilities :

$P_{UB}(w_1;w_1)$; $P_{UB}(w_2;w_1)$; $P_{UB}(w_3;w_1)$ ... $P_{UB}(w_K;w_1)$

i.e.

$$P_{UB}(w_1) = z \cdot \alpha_1 \left(1 - \frac{l''_{E-1}}{l''_1}\right) \sum_1^K \frac{l'_{E-i}}{l'_i} \cdot \alpha_i \qquad \ldots\ldots \quad (13a)$$

In general, the probability of the distance covered by a rake of humped wagons with a rolling resistance w_K having to be restricted amounts to :

$$P_{UB}(w_1) = z \cdot \alpha_K \left(1 - \frac{l''_{E-K}}{l''_K}\right) \sum_m^r \frac{l'_{E-i}}{l'_i} \cdot \alpha_i \qquad \ldots\ldots \quad (14)$$

where :

m signifies the number of the rolling resistance intervals from which onwards it becomes necessary to restrict the distance covered by the second rake, and

r the total number of intervals in the rolling resistance classification table.

With incomplete distance braking, it is thus necessary to take into account not only the rakes of wagons covering the distances $l_1, l_2, l_3, \ldots l_r$, but also those covering the reduced distances $l''_{E-1}, l''_{E-2}, l''_{E-3}, \ldots, l''_{E-r}$. All the rakes of wagons covering reduced distances seemingly increase the number of rakes with higher rolling resistances. The rolling resistance classification table is therefore modified and assumes the form reproduced in Table 5.

In this table, the probabilities of the given rolling resistances occurring are determined with the aid of the formula

$$\alpha_{UB-K} = \alpha_K - P_{UB}(w_K) + \sum_{j=m}^{j=r} P_{UB}(w_j) \qquad (15)$$

where

α_K signifies the probability of the occurrence of rakes of wagons with a rolling resistance w_K (covering a distance l_K) with complete distance braking;

$P_{UB}(w_K)$ the probability of the distance covered by a rake of wagons with the rolling resistance w_K having to be restricted, and

$\sum_{j=m}^{j=r} P_{UB}(w_j)$ the sum of the probabilities of the incomplete distance braking for those rakes of wagons for which the reduced distance is equal to l_K.

With the aid of Table 5, the length of the group of wagons to be closed up with incomplete distance braking can be determined in the same way as for complete distance braking.

The distance covered by the locomotive during the move from an adjacent siding amounts to $(2l_w + l_L)$, and during the move from another group of sorting sidings to $(2L_0 + l_L)$. The mean distance covered by the locomotive during the closing-up operation amounts to $L_0 + l_w + l_L$,

where :

L_0 signifies the track development of the hump yard, i.e. the distance from the point of the first distribution switch to the clearance mark beyond the last distribution switch;

l_w the distance between the clearance mark and the point of the last distribution switch, and

l_L the length of the locomotive.

TABLE 5.

Rolling resistance	w_1	w_2	...	w_r	$w_1 > w_2 > \ldots > w_r$
Probability of these rolling resistances occurring	α_{uB1}	α_{uB2}	...	α_{uBr}	$\alpha_{uB1} + \alpha_{uB2} + \ldots + \alpha_{uBr} = 1$
Distance covered by the rakes	l_1	l_2	...	l_r	$l_1 < l_2 < \ldots < l_r$

4. Time required for the closing-up of wagons by means of a locomotive working on the side of the hump.

The closing-up operation may take the following forms :

a) When closing up each group, the locomotive collects all the humped wagons and pushes them to the points clearance mark at the far end of the siding. The locomotive operation required for the handling of the first two groups by this method, and the time required for each operation, are shown in figure 2.

b) When closing up one group, the work of the locomotive is confined to closing up the rakes of wagons over the length of the group to be closed up. The necessary operations, and the time required for each operation, are shown in figure 3.

The first method calls for the following operations :

1. The locomotive must enter the siding;
2. The wagons must be closed up;
3. The locomotive must return from the siding.

The time required by the locomotive for the closing-up operation can be determined with the aid of the following formula :

$$a = \frac{L_0 + l_w + l_L}{60\, v_L} + t_H; \text{ [min]} \qquad (16)$$

where :

v_L signifies the mean speed of the locomotive (taking into account the times for acceleration and braking), in m/sec;

t_H the stopping time, in minutes, required when changing the direction of running.

It can be seen from figure 2 that the time required by the locomotive for the closing-up of the first group amounts to :

$$t_1 = a + \frac{1}{60}\left(\frac{1}{v_B} + \frac{1}{v_L}\right) \cdot (L_R - L_{Bg})$$
$$= a + b(L_R - L_{Bg}) \qquad (17a)$$

Similarly, the time required for the second group works out at :

$$t_2 = a + b\,(L_R - 2L_{Bg}) \qquad (17b)$$

and, correspondingly, for the *n*th group

$$t_n = a + b\,(L_R - n \cdot L_{Bg}) \qquad (17)$$

where :

v_B signifies the mean speed of the closing-up operation, in m/sec (taking into account the stops required for the removal of the brake shoes);

L_R the useful length of the sorting siding, in metres;

The number of groups to be closed up, forming part of a train of the length L_z, amounts to :

$$d = \frac{L_z}{L_{Bg}} - 1 \qquad (18a)$$

(the last group being removed from the sorting siding together with the train).

The time required for the closing-up operation, related to a desintegrated train, is equal to the sum of the times required for the closing-up of the different groups, i.e.

$$T = t_1 + t_2 + t_3 + \dots + t_d \quad (18b)$$

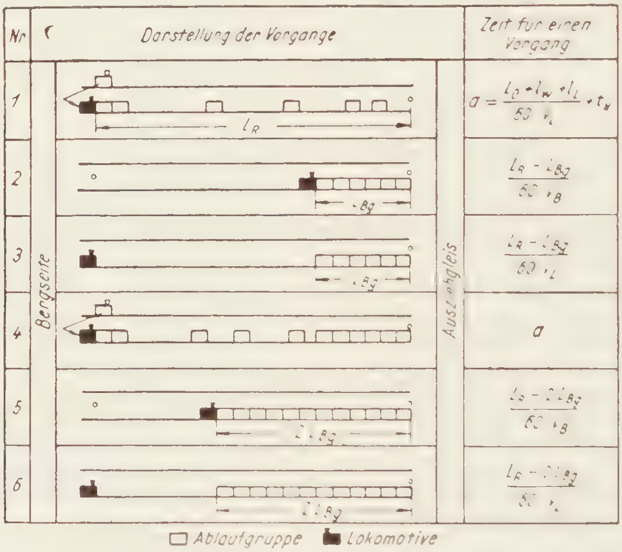

Fig. 2. — Operations to be carried out if wagons are closed up by a locomotive working on the hump side (first method).

N. B. — Darstellung der Vorgänge = illustration of the operations. — Zeit für einen Vorgang = time required for each operation. — Bergseite = side of hump. — Ausziehgleis = train formation track. — Ablaufgruppe = rake of humped wagons.

b the time required for the closing-up of the wagons and for the subsequent return of the locomotive to the clearance mark, in min/1 m of distance.

The value of b is determined from the formula :

$$b = \frac{1}{60}\left(\frac{1}{v_L} + \frac{1}{v_B}\right)\left(\frac{\text{min}}{\text{m}}\right) \qquad (17_c)$$

If the values for t_1, t_2, t_3, ... t_d are substituted in this formula, one obtains :

$$T = \left(\frac{L_z}{L_{Bg}} - 1\right)\,[a + b\,(L_R - 0.5\,L_z)]\ [\text{min}] \qquad (18)$$

If the hump yard is worked by two or three locomotives, some of the groups can already be closed up while the humping is still

going on. The number of groups, k, which can be closed up during that time depends on the nature of the flow of wagons to be handled and on the degree to which the sidings are specialized. It may range from 0.5 to 1.0 if two locomotives are working simultaneously, and from 0.7 to 1.5 if three locomotives are working simultaneously.

$$T_B = \left[\frac{L_z}{L_{Bg}} - (K+1)\right] \cdot (a + b\,L_{Bg}) \quad (21)$$

A comparison of figures 2 and 3 shows that, if the length of the group to be closed up is small ($L_{Bg} < 0.5\ L_R$), the distance to be covered by the locomotive, and hence the time required for the closing-up operation, is less with the second method than with the first.

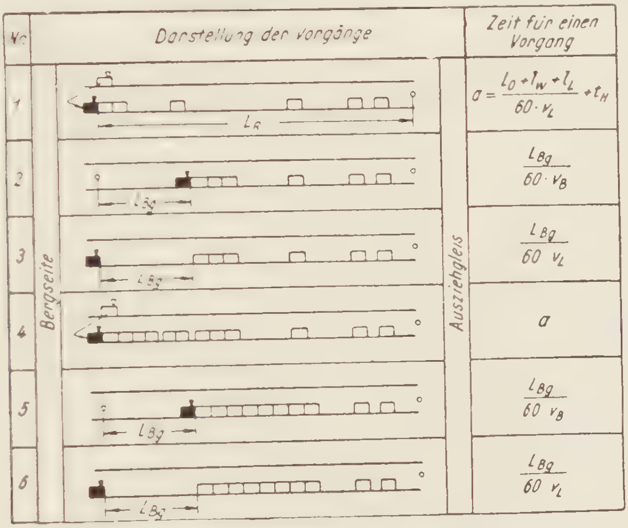

Fig. 3. — Operations to be carried out if wagons are closed up by a locomotive working on the hump side (second method).
For the translation of the German wording, see figure 2.

The time during which the hump is blocked by the closing-up operations, i.e. the time during which humping operations must cease because of the closing-up, can be determined from the following formula :

$$T_B = \left[\frac{L_z}{L_{Bg}} - (K+1)\right] \cdot [a + b(L_R - 0{,}5\ L_z)]\ [\text{min}] \quad (19)$$

In the same way, the time required for closing-up in accordance with the second method (cf. fig. 3) works out at :

$$T = \left(\frac{L_z}{L_{Bg}} - 1\right)(a + b\,L_{Bg}) \quad (20)$$

and the time during which the hump is blocked because of the closing-up operation works out at :

For instance, with $L_{Bg} = 180$ m; $L_Z = 600$ m; $L_K = 750$ m; $a = 2$ min [1]; $b = 0.023$ min/m (with $v_L = 5.5$ m/sec, $v_B = 0.84$ m/sec), the time required for the closing-up operation, related to a train dealt with in accordance with the first method, amounts to :

$$T = \left(\frac{600}{180} - 1\right)[2 + 0.023\,(750 - 0.5 \cdot 600)] = 28.8 \text{ min}$$

and in accordance with the second method to :

$$T = \left(\frac{600}{180} - 1\right) \cdot (2 + 0.023 \cdot 180) = 14.3 \text{ min}$$

(1) Guide for the technical normalisation of marshalling work. Moscow 1951.

The time during which, with $k = 1$, the hump is blocked by reason of the closing-up operation amounts, with the first method, to:

$$T_B = \left[\frac{600}{180} - (1 + 1)\right] \cdot [2 + 0.023 (750 - 0.5 \cdot 600)] = 16.4 \text{ min}$$

and with the second method to :

$$T_B = \left[\frac{600}{180} - (1 + 1)\right] \cdot [2 + 0.023 \cdot 180] = 8.2 \text{ min}$$

It follows that it is advantageous to confine the closing-up operation to the group concerned if $L_{Bg} < 0.5\ L_R$ but to extend it to the clearance mark if $L_{Bg} \geqslant 0.5\ L_R$.

5. Time required for the closing-up of wagons by means of a locomotive pulling them from the train formation side.

If the closing-up operation is carried out by a locomotive pulling the wagons from the side of the train formation track, this can be done by the following methods :

a) The locomotive pushes all the wagons in one siding together and pulls them coupled to the clearance mark.

b) The locomotive pushes all the wagons in one siding together and pulls them, in each case, over a distance corresponding to the length of the group to be closed up.

The operations required for the handling of the first two groups of wagons, and the times required for each operation, are shown in figure 4 for the first method, and in figure 5 for the second method.

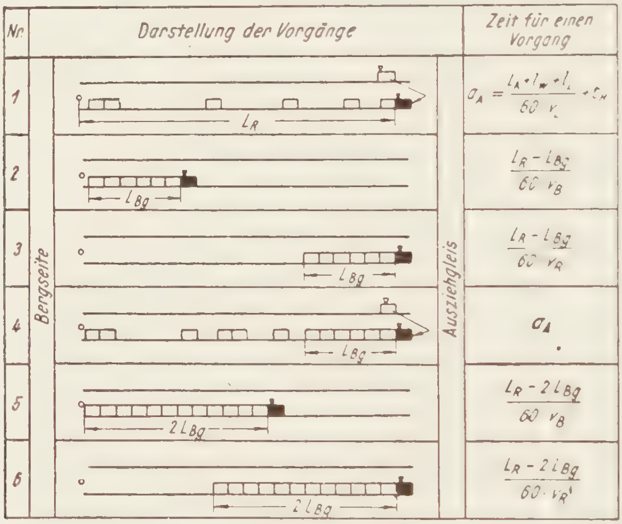

Fig. 4. — Operations to be carried out if wagons are pulled forward by a locomotive working on the train formation side (first method).

For the translation of the German wording, see figure 2.

If L_{Bg} is greater than or equal to $0.5\ L_R$, the times required for the closing-up operation are the same after both methods as the operation is carried out up to the clearance mark over a length of $(L_R - L_{Bg})$. With $L_{Bg} > 0.5\ L_R$, the closing-up time must therefore be calculated with the aid of the following formulas :

$$T = \left(\frac{L_z}{L_{Bg}} - 1\right) [a + b\ (L_R - L_{Bg})] \qquad (22)$$

$$T_B = \left[\frac{L_z}{L_{Bg}} - (K + 1)\right] \cdot [a + b (L_R - L_{Bg})] \quad \ldots \qquad (23)$$

When pulling the wagons in accordance with the first method, the following operations must be carried out :

1. The locomotive must enter the siding;
2. The wagons must be pushed together towards the hump, and coupled up;
3. The group of coupled wagons must be pulled forward to the clearance mark.

The times for these operations can be worked out from the formulas shown in figure 4.

The time required for the pulling out of the wagons related to a desintegrated train, is worked out in the same way as the time required for the pushing of the wagons from the hump side, and amounts to :

$$T = \left(\frac{L_z}{L_{Bg}} - 1\right)[a_A + b_A (L_R - 0.5\,L_Z)]; \quad \ldots \quad [\text{min}] \qquad (24)$$

where :

a_A signifies the time required by the locomotive for pulling the wagons in the direction of the train formation track;

b_A the time required for pushing the wagons towards the hump and for pulling the coupled wagons, related to 1 m of distance covered (min/m).

The values of a_A and b_A are worked out as follows :

$$a_A = \frac{L_A + l_W + l_L}{60\,v_L} + t_H; \qquad (24a)$$

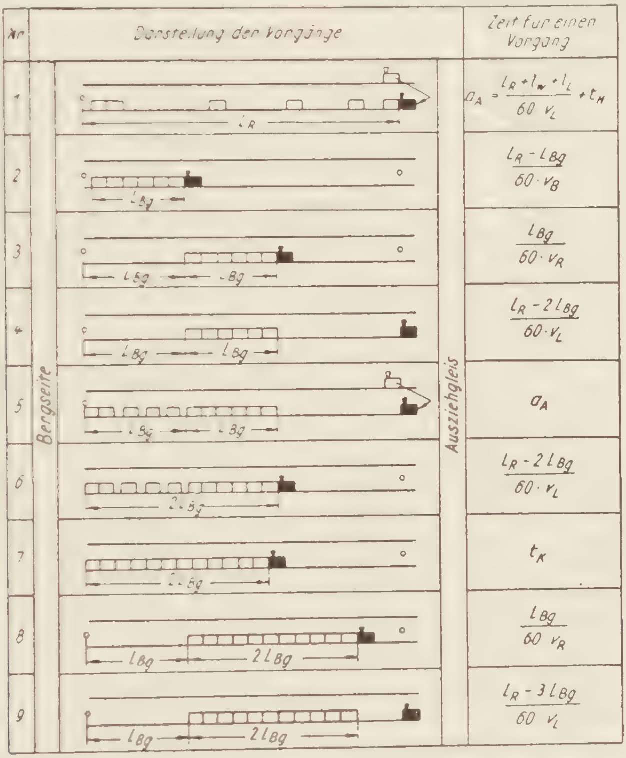

Fig. 5. — Operations to be carried out if wagons are pulled forward by a locomotive working on the train formation side (second method .

For the translation of the German wording, see figure 2.

$$b_A = \frac{1}{60}\left(\frac{1}{v_B} + \frac{1}{v_R}\right); \qquad (24b)$$

where :

L_A signifies the track development from the train formation side, and

v_R the mean speed of the shunting operation in m/sec.

If the wagons are handled in accordance with the second method, the following operations must be carried out :

1. The locomotive must enter the siding;
2. The locomotive must run from the clearance mark to the wagons standing in the siding;
3. The wagons must be closed up and coupled up;
4. The group of coupled wagons must be pulled forward over the distance corresponding to the length of the group to be closed up;
5. The locomotive must return to the clearance mark.

To shorten the time for pulling the first group forward, it is advisable to hold, during the gathering of the wagons, the first-humped groups at a distance of L_{Bg} from the clearance mark on the hump side. In that case, the time for pulling the first group forward amounts to :

$$t_1 = a_A + \frac{L_R - L_{Bg}}{60 v_L} + t_K \cdot L_{Bg} + \frac{L_{Bg}}{60 v_R} + \frac{L_R - 2L_{Bg}}{60 v_L} = a_A + \left(t_K + \frac{1}{60 v_R}\right) L_{Bg} + \frac{2L_R - 3L_{Bg}}{60 v_L}; \qquad (25a)$$

or

$$t_1 = a_A + b_R \cdot L_{Bg} + b_L(2L_R - 3L_{Bg}); \qquad (25b)$$

where :

t_K signifies the time required for the coupling of the wagons, related to 1 m of their length, in min/m;

b_R the time required for the closing up and pulling forward of the wagons, related to 1 m distance, in min/m;

b_L the turn-round time of the locomotive, related to 1 m distance, in min/m.

The values of b_R and b_L are given by the formulas :

$$b_R = t_K + \frac{1}{60\, v_R}; \qquad (25c)$$

$$b_L = \frac{1}{60\, v_L}. \qquad (25d)$$

Correspondingly, the time required for pulling forward the second group amounts to :

$$t_2 = a_A + b_R L_{Bg} + b_L(2L_R - 5L_{Bg}); \qquad (26)$$

The times required for pulling forward the following groups are worked out similarly.

The time required for pulling the wagons forward, related to a disintegrated train, is equal to the sum of the times required for pulling forward each individual group, i.e.

$$T = \left(\frac{L_Z}{L_{Bg}} - 1\right)[a_A \cdot b_R \cdot L_{Bg} + b_L(2L_R - L_Z - L_{Bg})]; \qquad (27)$$

It will be seen from figures 4 and 5, that the time required for pulling forward the wagons is shorter by the second method than by the first. For instance, with $L_{Bg} = 180$ m, $L_Z = 600$ m; $L_R = 750$ m; $a_A = 1.5$ min; $b_A = 0.025$ min/m (with $v_L = 5.5$ m/sec; $v_R = 4$ m/sec); $b_R = 0.016$ min/m; (with automatic coupling) $b_L = 0.003$ min/m, the time required for pulling the wagons forward by the first method works out at :

$$T = \left(\frac{600}{180} - 1\right)[1.5 + 0.025 \cdot (750 - 0.5 \cdot 600)] = 29.8 \text{ min}$$

and by the second method at :

$$T = \left(\frac{600}{180} - 1\right)[1.5 + 0.016 \cdot 180 + 0.003(2 \cdot 750 - 600 - 300)] = 14.4 \text{ min.}$$

If $L_{Bg} \geqslant 0.5\, L_R$, the wagons are pulled forward to the clearance mark over the

distance ($L_R - L_{Bg}$). With $L_{Bg} > 0.5\ L_R$ the time required for pulling the wagons forward must therefore be determined with the aid of the formula :

$$T = \left(\frac{L_Z}{L_{Bg}} - 1\right) \left[a_A + (b_R + b_L)\ (L_R - L_{Bg})\right] \qquad (28)$$

6. Time required for closing up the wagons by means of a tractor with traversing.

During the closing-up of the first group of wagons, having the length L_{Bg}, the following operations must be carried out (cf. fig. 6) :

1. Having closed up the previous group on one of the sidings, the tractor must run via the nearest roadway crossing to another roadway between the sidings;

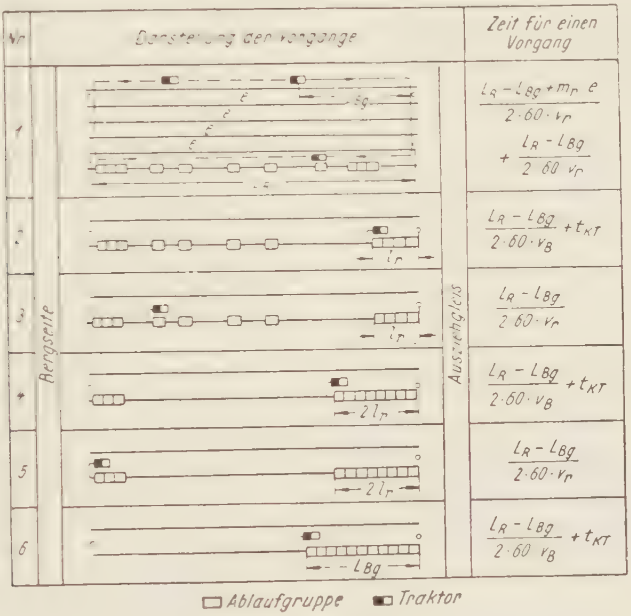

Fig. 6. — Operations to be carried out if wagons are closed up by a tractor.

For the translation of the German wording, see figure 2.

N. B. — Traktor = tractor.

2. The tractor must run from the roadway passage to the group of wagons to be closed up.
3. The tractor must be coupled, the wagons must be closed up, and the tractor must be uncoupled.
4. The tractor must move to carry out the closing-up operation on the following

It follows that, if $L_{Bg} < 0.5\ L_R$, it is advisable to pull the wagons forward over the distance corresponding to the length of the group to be closed up but that, if $L_{Bg} \geqslant 0.5\ L_R$, it is preferable to pull them forward to the clearance mark on the train formation side. In order to shorten the time for pulling forward the first-humped groups, it is desirable to collect the first groups at a distance of L_{Bg} from the clearance mark on the hump side.

rake, having the length l_T, in the same siding.

When closing up the following rakes on the same siding, the third and fourth operations are repeated. The number of these rakes amounts to :

$$\frac{L_{Bg}}{l_T}$$

where :

l_T signifies the length of the rake of wagons that can be moved by the tractor.

The time required for the tractor to move to the nearest roadway crossing depends on the distance. The greatest possible distance is $(L_R - L_{Bg})$, whilst the smallest possible distance is zero. The mean distance covered by the tractor in reaching the nearest roadway crossing is therefore :

$$\frac{L_R - L_{Bg}}{2}$$

The same distance must be covered by the tractor on the way from the roadway crossing to the group to be closed up. The distance which the tractor must cover in using the roadway passage depends on the number of sidings, m_T, served by the tractor, and on the spacing of the tracks, e, the mean distance being :

$$\frac{m_T \cdot e}{2}$$

The distance to be covered by the tractor during the closing-up of each rake, having the length l_T, varies for the first rake with the length L_{Bg} from 0 to. $(L_R - L_{Bg})$, the mean distance being :

$$\frac{L_R - L_{Bg}}{2}.$$

The same distance is covered by the tractor during each run for the closing-up of the following rakes (having the length l_T) in the same siding.

Figure 6 gives the formulas for determining the times required for each of these operations. The total time required for closing-up of the first rake, having the length L_{Bg}, amounts to :

$$t_1 = \frac{L_R - L_{Bg}}{2}\left[\frac{1}{60 v_T} + \frac{L_{Bg}}{60 l_T}\left(\frac{1}{v_B} + \frac{1}{v_T}\right)\right] + t_{KT} \cdot \frac{L_{Bg}}{l_T} + \frac{m_T \cdot e}{2 \cdot 60 \cdot v_T}; \qquad (29a)$$

or :

$$t_1 = \frac{L_R - L_{Bg}}{2}\,[a_T + b_T \cdot L_{Bg}] + a_K + a_e, \qquad (29b)$$

where :

v_T signifies the running speed of the tractor in m/sec;

v_B the speed of the tractor during closing-up operations, in m/sec;

t_{KT} the time required for the coupling-up and uncoupling of the tractor and for the change of direction, in minutes;

a_T a coefficient, taking into account the time required by the tractor for the run to the roadway crossing after the closing-up of the previous rake;

b_T a coefficient, taking into account the time required by the tractor for closing up a rake of wagons and for the run to the next rake in the same siding;

a_K a coefficient taking into account the time required for the coupling-up and uncoupling of the tractor and for the change of direction;

a_e a coefficient taking into account the time required by the tractor for moving from one siding to the next.

The values for a_T, b_T, a_K, a_e are determined from the following formulas :

$$a_T = \frac{1}{60 \cdot v_T} \qquad (29c)$$

$$b_T = \frac{1}{60\, l_T}\left(\frac{1}{v_B} + \frac{1}{v_T}\right) \qquad (29d)$$

$$a_K = \frac{t_{KT}}{l_T} \qquad (29e)$$

$$a_e = \frac{m_T \cdot e}{2 \cdot 60 \cdot v_T} \qquad (29f)$$

The time required for the closing-up of the following rakes, having the length L_{Bg}, is

determined in a similar way and amounts to where :

$$t_n = \frac{L_R - n \cdot L_{Bg}}{2} [a_T + b_T \cdot L_{Bg}] + a_K + a_e \quad (30)$$

where :

n signifies the consecutive number of the rake having the length L_{Bg}.

The time required for closing up the wagons, related to a desintegrated train, is equal to the sum of the times required for the closing-up of the individual rakes with the length L_{Bg}, i.e.

$$T = \left(\frac{L_Z}{L_{Bg}} - 1\right) [0.25(2L_R - L_Z)(a_T + b_T \cdot L_{Bg}) + a_K L_{Bg} + a_e] \quad (31)$$

If the wagons are closed up by the tractor over the length of the train, and not over the length of the siding, the time required for the closing-up operation amounts to

$$T = \left(\frac{L_Z}{L_{Bg}} - 1\right) [0.25\, L_Z\, (a_T + b_T \cdot L_{Bg}) + a_K \cdot L_{Bg} + a_e] \quad (32)$$

7. Conclusions.

The formulas quoted above can be used for calculating the times required for the closing-up of wagons under different conditions in existing or planned hump yards.

If group trains are formed on several sidings, or if single-group trains are formed in short sorting sidings ($L_R < L_Z$), the time required for the closing-up operation, related to a train group (T_G), can be determined with the aid of the same formulas, except that L_Z must be replaced by the length of the train group, L_G. The time required for closing-up or pulling forward, related to a train of the length L_Z, amounts in this case to :

$$T = \frac{L_Z}{L_G} \cdot T_G.$$

If the calculations based on these formulas yield $a \leqslant 0$, the time required for closing-up is zero because the length of the group to be closed up is greater than, or equal to, the length of the train or, in the case of train groups being formed in several sidings, greater than or equal to the length of the train group.

With the aid of the proposed formulas, it is possible to determine, by means of scientifically correct calculations, the time required for the closing-up operations, and thus to work out standard rules for shunting operations, to select suitable shunting locomotives and methods, and to solve other problems concerning existing or planned hump yards.

NEW BOOKS AND PUBLICATIONS.

[**385** (08 (492)]

N.S. 1960 — JAARVERSLAG *(Netherlands Railways - Annual report 1960)*. — One brochure (8 1/4 × 11 in.) of 72 pages, with maps and numerous figures. — 1961, Utrecht, Nederlansche Spoorwegen, Moreelsepark.

The annual management report for the year 1960, which the *Nederlandsche Spoorwegen N. V.* has just issued, shows as usual the lines on which this system is developing. The financial situation, which is satisfactory with a surplus of 12.6 million florins, shows that the increase in the receipts is progressing from year to year; for the first time, the years receipts have exceeded half a thousand million florins (an increase of 3.8 %); the traffic units amounted to 11.23 thousand millions (increase of 5.3 %), thus exceeding the previous maximum figure of 1956.

The spaced timetables for the passenger services, which are so characteristic of the working of the N.S., have been revised relatively profoundly, in order to reduce the time taken for inter-province journeys. Plans have been prepared for the reconstruction of The Hague SS Station, and other improvements are under consideration. The replacing of level crossings by bridges is continuing at an accelerated rate.

It would appear, however, that it is the goods traffic which requires studying the most. New silo-wagons have been put into service as well as a prototype special type of covered wagon for goods of low specific weight, which will be easier and quicker to load and unload, and will therefore be a help to clients. Important organisation measures, intended to improve the quality of goods transport have been studied and are being progressively introduced: these concern preliminary notification of loads and closer contact with consignors. Co-ordination offices now regulate the traffic, in particular at Rotterdam, thus reducing not only the delay in making wagons available and getting them off, but also the haulage charges. Amongst the main technical means mention may be made of the teleprinter system which has been extended. The number of station centres for the parcels traffic has been reduced, but their equipment has been modernised to reduce the handling time.

Although the number of jobs available has been reduced by increased mechanisation and improved productivity, the N.S. have not been able to find the necessary 1 400 employees required to fill vacant posts, in spite of the fact that some 1 700 new employees entered the service.

It may be mentioned that in April of the year under review, wages and conditions of employment were considerably improved. The pensionable age limits were raised from 63 to 65 years.

As regards the technical equipment, we may mention the generalisation of long rails, the setting up of a large modern marshalling yard at Rotterdam, the introduction of centralised traffic control on the Nimegue-Blerick single line, the extension of automatic half-barriers at level crossings, a further 30 of which were put into service during 1960, as well as 38 sets of winking light equipment, the improvements which have enable the speed limits on the Dordrecht-Geldermalsen line to be increased to 100 km/h, the introduction of additional Diesel-electric multiple sets, and some 250 wagons, but above all the intensification of the work of research and analysis both in chemical laboratories and those equipped for mechanical tests. Finally, the extension of the use of electronic equipment for managerial work should be noted.

The subsidiary undertakings have also made progress, especially as regards renewal of the stock of buses. A new associated company has been set up to deal with the private sidings installations for important clients.

P. Sch.

[38]

SEIDENFUS (H. St.) Professor of Political Economy at Giessen University. — ENERGIE ET TRANSPORT. **Modifications structurelles du Trafic Européen. Rétrospectives et Perspectives.** (POWER AND TRANSPORT. *Structural modifications in European Traffic. Retrospects and Perspectives.*) — Translated from the German by A. COLNAT. One volume (6 1/4 × 9 7/8 in.) of 308 pages with 12 maps. — 1961, Paris (6e) Dunod, Publisher, 92 rue Bonaparte (Price: bound 25 NF).

The changes that have occurred in sources of power (in particular coal, petroleum and natural gases) and the development of new methods of transport (such as pipe-lines) must necessarily have an important effect upon the structure and volume of traffic of means of transport (railways, inland navigation, road transport) of Western Europe.

It is problems such as these that Professor SEIDENFUS studies on the most up-to-date scientific lines in this book, the preface of which has been written by MM. E. ARON, Professor of Sociology at the Sorbonne, and E. SALIM, Professor of Political Science at the University of Basle and General Secretary of the List Society.

This abundant documentation, gathered together in close collaboration between the List Institute at Basle and the Railway Administrations and Transport Organisations of Germany, Austria, Belgium, France, Italy, Holland and Switzerland, and given in the form of maps and tables, forms a mine of information and statistics collected from the national and international organisations and various industrial companies producing and transforming power (in particular the petroleum industry).

In a penetrating analysis of the present day structures, the « tendencies » capable of supplying the necessary factors for a co-ordination of the transport and power policy of the next few years, are clearly brought out, and the author makes his forecasts for the future, with prudence and on a scientific basis according to his observation of the facts.

The international collaboration of transport and power specialists is very much to the fore, and the putting into profit of new power resources today places France at the centre of a dynamic evolution in this field. It is therefore a good thing that the work of H. S. SEIDENFUS should be widely known.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

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[**016** .385 (02]

I. — BOOKS.

In French.

1961 — 625 .244 (06

SOCIÉTÉ FERROVIAIRE INTERNATIONALE DE TRANSPORTS FRIGORIFIQUES. (Interfrigo).

Rapport présenté par le Conseil d'Administration à l'Assemblée Générale Ordinaire du 23 juin 1961. Exercice 1960.

Bruxelles, édité par la Société ci-dessus, 17, rue de Louvain. Une brochure (21 × 29.5 cm), de 28 pages.

1961 — 691

TYVAERT (P.).

Protection des surfaces métalliques contre la corrosion. Procédés non-électrolytiques.

Paris, Publications Estoup, éditeur, 47, rue du Château-des-Rentiers. Un volume (21 × 27 cm) de 180 pages, avec de nombreuses figures. (Prix : 18 NF.)

1961 — 62 (01

VOLTERRA (V. et E.).

Sur les distorsions des corps élastiques. Théorie et applications.

Paris, Gauthier-Villars, éditeur, 55, quai des Grands-Augustins. Un volume (16 × 25 cm) de 118 pages, avec 35 figures. (Prix : 24 NF.)

In German.

1961 — 621 (02 & 625 .2 (02

Elsners Taschenbuch für den maschinentechnischen Eisenbahndienst. 19. Band 1961.

Frankfurt (Main), Dr. Arthur Tetzlaff-Verlag, Niddastrasse 64. 472 Seiten, mit vielen Abbildungen, Tafeln und Tabellen. Taschenformat. (Preis : DM 8.—; Vorzugspreis für Eisenbahner, DM 5.40.)

1960 — 624

Dr.-Ing. K. KLÖPPEL und Dr.-Ing. J. SCHEER.

Beulwerte ausgesteifter Rechteckplatten.

Berlin, Verlag Wilhelm Ernst und Sohn. Ein Band (22 × 31 cm) von 107 Seiten, mit 45 Abbildungen und 103 Tafeln.

1960 — 531

RÜDIGER (D.) und KNESCHKE (A.).

Technische Mechanik. Band 1 : *Statik starrer Körper.*

Leipzig, B.G. Teubner Verlagsgesellschaft. 324 Seiten (16.5 × 22.5 cm) mit 421 Bildern. (Preis : Ganzleinen, DM 25.90.)

1960 — 656

VOIGT (F.).

Die volkswirtschaftliche Bedeutung des Verkehrssystems.

Berlin, Duncker & Humblot. 328 Seiten. (Preis : brosch., DM 36.—.)

In English.

1961 — 385 (09 (42)

NOCK (O.S.).

British Steam Railways.

One volume (9 1/2 × 6 1/2 in.) of 326 pages, illustrated.

London : Adam & Charles Black Limited, Soho Square, W. 1. (Price : 42 s.)

1961 — 65

PAYNE (P.L.).

Rubber and Railways in the Nineteenth Century.

One volume (8 1/2 × 5 1/4 in.) of 246 pages, illustrated.

Liverpool 7 : Liverpool University Press, 123, Grove Street. (Price : 30 s.)

1961 — 656 .2

PHILLIPS, Jr. (E.J.).

Railroad operation and railway signalling.

New York : Simmons-Boardman Publishing Corporation, 30, Church Street, N.Y. 7. (Price : $ 3.75.)

1961 — 385 (08 (54)

Report by the Railway Board on Indian Railways for 1959-1960.

Volumes I and II. — 587 pages, illustrated.

New Delhi : Published by The Manager of Publications, Indian Railways. (No price stated.)

---

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels, (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, p. 1509).

1961 621 .132 .1 (931)

Steam locomotives of New Zealand Railways since 1863.

One brochure (9 × 6 in.) of 46 pages, illustrated.

Obtainable direct by mail from the Publications Officer New Zealand Railway and Locomotive Society Inc., P.O. Box 5134, Wellington, C. 1. (Price : 8 s. 6 d. post free.)

In Spanish.

1961 627 .82 (06

7° Congreso Internacional de grandes presas (Roma, junio de 1961).

Numero extraordinario de la *Revista de Obras Publicas.* (Junio de 1961).

Madrid, *Revista de Obras Publicas*, Alfonso XII, 3-7. Uno volumen (21.5 × 27.5 cm) de 220 paginas, con numerosas ilustraciones y cuadros.

[016 .385 (05]

II. — PERIODICALS.

In French.

Bulletin de l'Association Suisse des Electriciens. (Zürich.)

1961 621 .319
Bull. de l'Ass. Suisse des Electriciens, 29 juillet, p. 561.
BOYER (P.). — **La « mémoire » et l'absorption diélectrique d'un condensateur.** (1 450 mots & fig.)

1961 621 .315
Bull. de l'Ass. Suisse des Electriciens, 29 juillet, p. 563.
METZLER (H.). — **Über Leit- und Widerstandslacke.** (900 mots & fig.)

Bulletin de l'Office de Recherches et d'Essais de l'U.I.C. (Utrecht.)

1961 656 .259
Bulletin de l'O.R.E., n° 13, juillet, p. 11.
Sensibilité au shuntage des circuits de voie. (1 400 mots.)

1961 625 .21
Bulletin de l'O.R.E., n° 13, juillet, p. 13.
Résistance des caisses du matériel roulant pour voyageurs. (700 mots.)

1961 621 .135 (01
Bulletin de l'O.R.E., n° 13, juillet, p. 14.
Dispositions constructives propres à améliorer **la stabilité et la qualité de guidage des engins moteurs électriques et Diesel.** (2 200 mots & fig.)

1961 625 .282
Bulletin de l'O.R.E., n° 13, juillet, p. 18.
Standardisation des locomotives Diesel. (2 000 mots & fig.)

1961 625 .234
Bulletin de l'O.R.E., n° 13, juillet, p. 21.
Chauffage des voitures et des autorails. (2 000 mots & fig.)

1961 691
Bulletin de l'O.R.E., n° 13, juillet, p. 24.
Protection des matériaux. (1 500 mots.)

C.F.F. (Berne.)

1961 656 .222 .5 (494)
C.F.F., août, p. 3.
KÄGI (W.). — **Berne et son trafic de banlieue.** (1 000 mots & fig.)

1961 625 .2 (494)
C.F.F., août, p. 6.
GERBER (F.). — **Le programme de renouvellement du matériel roulant des C.F.F.** (1 600 mots & fig.)

Chemins de fer. (Paris.)

1961 385 (09 (494)
Chemins de fer, n° 228, mars, p. 77.
WENGER (W.). — **Les Chemins de fer Fédéraux Suisses en 1960.** (3 200 mots & fig.)

1961 621 .335
Chemins de fer, n° 228, mars, p. 90.
LAMY-DURAY (J.S.). — **La locomotive BB 20005 bicourant 25 kV-50 Hz-1 500 V-courant continu.** (2 000 mots & fig.)

1961 625 .231 (44)
Chemins de fer, n° 228, mars, p. 95.
BRUHAT (L.). — **Nouveaux fourgons Dd4 à la S.N.C.F.** (1 500 mots & fig.)

1961 625 .17
Chemins de fer, n° 228, mars, p. 98.
PORCHER (B.). — **L'entretien des voies :** la révision intégrale. (1 200 mots & fig.)

Organisation Scientifique. (Bruxelles.)

1961 385 .587
Organisation Scientifique, juin-juillet, p. 161.
HAGNAUER (W.). — **Entraînement du personnel spécialisé.** (3 000 mots.)

Rail et Traction. (Bruxelles.)

1961 **656** .2 (481)
Rail et Traction, mai-juin, p. 97.
VAN GEEL (P.). — **Les Chemins de fer Norvégiens de l'Etat.** (*Suite.*) (3 000 mots, tableaux & fig.)

1961 **625** .42 (492)
Rail et Traction, mai-juin, p. 127.
HAUSMAN (R.G.). — **Un métro à Rotterdam.** (500 mots & fig.)

Revue Générale des Chemins de fer. (Paris.)

1961 **625** .212 (44)
Revue Générale des Chemins de fer, juillet-août, p. 389.
PLU et LADOUES. — Nouvelle réalisation pour le **reprofilage des roues sans retrait des essieux.** (5 000 mots, tableaux & fig.)

1961 **625** .258
Revue Générale des Chemins de fer, juillet-août, p. 401.
JUTIER (J.) et CAUCHOIS (G.). — **Les freins de voie Saxby « R 58 ».** (3 500 mots & fig.)

1961 **656** .211 (44)
Revue Générale des Chemins de fer, juillet-août, p. 410.
TOPET. — L'achèvement de la reconstruction sur la Région de l'Ouest de la S.N.C.F. **Les petits bâtiments de voyageurs.** (1 500 mots & fig.)

1961 **656** (4)
Revue Générale des Chemins de fer, juillet-août, p. 431.
Orientation à donner à la **politique commune des transports en Europe.** (3 000 mots.)

1961 **385** .15 (42)
Revue Générale des Chemins de fer, juillet-août, p. 443.
DELACOUR. — Livre blanc britannique sur la **réorganisation des entreprises de transport nationalisées.** (1 200 mots.)

1961 **625** .282 (86)
Revue Générale des Chemins de fer, juillet-août, p. 448.
Locomotives Diesel-électriques des Chemins de fer de l'Equateur. (1 300 mots & fig.)

La Traction Electrique dans les Chemins de fer. (Bruxelles.)

1961 **621** .335
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 6, juin, p. 261.
MIGNON (G.) et LAMBERTS (P.). — Les **locomotives monophasées** 50 Hz à redresseurs au silicium série 2400 du B.C.K. (3 900 mots & fig.)

1961 **621** .335 (43)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 6, juin, p. 284.
WITTIG (P.). — La partie véhicule de **l'automotrice à accumulateurs** ETA 150 et de la remorque à poste de conduite ESA 150. (5 400 mots & fig.)

1961 **621** .338 (52)
Bulletin du Congrès des Chemins de fer. — La Traction Electrique dans les Chemins de fer, n° 6, juin, p. 306.
Les Chemins de fer Nationaux Japonais recherchent la meilleure conception de l'équipement de traction destiné à leurs **automotrices à courant alternatif.** (1 200 mots & fig.)

Les Transports Publics. (Berne.)

1961 **385** .581
Les Transports Publics, août, p. 6.
Réduction de la durée du travail et frais de personnel. (1 200 mots & fig.)

La Vie du Rail. (Paris.)

1961 **625** .144 (44)
La Vie du Rail, 16 juillet, p. 3.
Quelques détails sur **l'engin poseur de traverses** du 5e régiment de génie. (500 mots & fig.)

1961 **625** .1 (44)
La Vie du Rail, 16 juillet, p. 8.
MORVERAND (M.). — **Suppression des passages à niveau de Dijon.** Mise en service partielle des nouveaux ouvrages d'art. (250 mots & fig.)

1961 **625** .42 (460)
La Vie du Rail, 16 juillet, p. 12.
Le « Suburbano » madrilène. (150 mots & fig.)

1961 **621** .38 (44)
La Vie du Rail, 23 juillet, p. 3.
Ensemble électronique de gestion de la S.N.C.F. (3 000 mots & fig.)

1961 **625** .13 (44)
La Vie du Rail, 23 juillet, p. 8.
Reconstruction du pont de Contrisson. (300 mots & fig.)

1961 **656** (42 + (44)
La Vie du Rail, 23 juillet, p. 13.
FRANÇOIS (M.). — **Le rail et les services aériens « Trans-Manche ».** (1 500 mots & fig.)

1961 **656** .257 (44)
La Vie du Rail, 30 juillet, p. 3.
La **commande centralisée** de la section Frasne-Vallorbe. (800 mots & fig.)

1961 **621** .33 (435 .9)
La Vie du Rail, 30 juillet, p. 6.
Electrification de l'artère industrielle Est-Ouest au Luxembourg. (1 500 mots & fig.)

1961 **625** .42 (44)
La Vie du Rail, 30 juillet, p. 10.
ROBERT (J.). — **Le réseau express régional** de Paris (R.A.T.P.). (2 000 mots & fig.)

1961 656 .256 .3 (44)
La Vie du Rail, 13 août, p. 3.
Le block automatique lumineux sur Paris-Marseille. Rétrospective et dernière étape. (700 mots & fig.)

1961 625 .242 (44)
La Vie du Rail, 13 août, p.6.
Wagon-tombereau à toit ouvrant «C.I.M.T. FOREST». (600 mots & fig.)

In German.

Archiv für Eisenbahnwesen. (Berlin.)

1961 385 (09 (493)
Archiv für Eisenbahnwesen, Heft 2, S. 159.
de WAELE (A.). — **Die Nationalgesellschaft der belgischen Eisenbahnen.** (18 000 Wörter, Tafeln & Karte.)

1961 656 (06 (4)
Archiv für Eisenbahnwesen, Heft 2, S. 205.
WOELKER (Ch.). — **Die verkehrspolitischen Regelungen in den Mitgliedsländern der EWG.** (Stand : 1. März 1961.) (6 000 Wörter & Tafeln.)

Die Bundesbahn. (Darmstadt.)

1961 656 .2 (43)
Die Bundesbahn, Nr. 13/14, Juli, S. 573.
SCHERSCHMIDT (G.). — **Donau-Verkehr und Deutsche Bundesbahn** im Jahr 1960. (3 000 Wörter, Tabellen & Abb.)

1961 656 .1 (43)
Die Bundesbahn, Nr. 13/14, Juli, S. 579.
STUCKE (F.). — Die Neufasssung der Begriffsbestimmungen für den **Linien- und Gelegenheitsverkehr mit Kraftomnibussen** im neuen Personenbeförderungsgesetz. (7 000 Wörter.)

1961 656 .234 (43)
Die Bundesbahn, Nr. 13/14, Juli, S. 593.
POLLAK (K.). — Der Einfluss beförderungsteuerrechtlicher Bestimmungen auf die **tarifliche Entwicklung der Streckenzeitkarten des Berufsverkehrs.** (2 500 Wörter.)

1961 385 (09 (47)
Die Bundesbahn, Nr. 13/14, Juli, S. 604.
Eine Studienreise in die Sowjetunion. (10 000 Wörter & Abb.)

Deutsche Eisenbahntechnik. (Berlin.)

1961 625 .26 (43)
Deutsche Eisenbahntechnik, Juli, S. 321.
WEISS (E.) und BALZKE. — **Die Einführung der Mitrofanow-Methode im Raw Cottbus.** (1 500 Wörter & Abb.)

1961 625 .1 (43)
Deutsche Eisenbahntechnik, Juli, S. 323.
SCHANDERT (H.). — **Durchsetzung des wissenschaftlich-technischen Fortschritts,** Hauptaufgabe des Hauptdienstzweiges Bahnanlagen der Deutschen Reichsbahn. (5 000 Wörter & Abb.)

1961 625 .142 .4 & 656 .25
Deutsche Eisenbahntechnik, Juli, S. 331.
HENNIG (E.). — **Das elektrische Verhalten von Stahlbetonschwellen in Gleisstromkreisen.** (6 000 Wörter & Abb.)

1961 625 .236 (43)
Deutsche Eisenbahntechnik, Juli, S. 341.
REHNERT (W.). — **Die Mechanisierung der Aussenreinigung der Reisezugwagen** bei der Deutschen Reichsbahn und ihre Rückwirkung auf den Reisezugwagenpark. (5 000 Wörter, Tafel & Abb.)

1961 656 .2
Deutsche Eisenbahntechnik, Juli, S. 355.
POTTHOFF (G.). — **Grundzüge der Eisenbahnbetriebsuntersuchungen.** (3 000 Wörter.)

1961 625 .23
Deutsche Eisenbahntechnik, Juli, S. 359.
DÖRING (W.). — Untersuchung der Verfahren für die **Berechnung selbsttragender Seitenwände von Reisezugwagen.** (5 000 Wörter, Tafel & Abb.)

Der Eisenbahningenieur. (Frankfurt am Main.)

1961 625 .1 & 656 .2
Der Eisenbahningenieur, Juli, S. 190.
KNIFFLER (A.). — **Moderne Technik — Moderne Eisenbahn.** (1 400 Wörter.)

1961 385 (06 (43)
Der Eisenbahningenieur, Juli, S. 194.
Eisenbahntechnische Fachtagung auf der Deutschen Industrie-Messe Hannover 1961. Auch 1962 wieder ! (2 000 Wörter & Abb.)

1961 621 .335
Der Eisenbahningenieur, Juli, S. 205.
KONRAD (H.). — **Elektrische Lokomotiven.** (650 Wörter & Abb.)

1961 656 .254
Der Eisenbahningenieur, Juli, S. 207.
GORETZKI (C.W.). — **Isotope im Signalmeldesystem.** (240 Wörter.)

1961 621 .332
Der Eisenbahningenieur, Juli, S. 208.
FRAUNHOLZ (J.). — **Die Fernsteuerung der Masttrennschalter in Fahrleitungsanlagen.** (600 Wörter & Abb.)

·961 621 .9 (06 (493)
:r Eisenbahningenieur, August, S. 215.
RIDDER (H.) und WARNECKE (O.). — **Die** **ropäische Werkzeugmaschinen-Ausstellung in Brüssel** , der Sicht des Eisenbahningenieurs. (5 000 Wörter Abb.)

·961 625 .14 (43)
:r Eisenbahningenieur, August, S. 223.
3RUX (G.). — Der **Oberbaudienst** bei der Deutschen ındesbahn. Gliederung, Aufgaben, Verbesserungen ıd Selbstkosten der Oberbaulager. (4 000 Wörter, ɪfeln & Abb.)

1961 625 .26
r Eisenbahningenieur, August, S. 232.
3RUNS (W.). — **Aus der Praxis des Werkstätten-** **ɪnstes.** (1 500 Wörter & Abb.)

1961 351 .712 (43)
:r Eisenbahningenieur, August, S. 235.
WIENECKE (H.). — **Das Bundesbaugesetz** — Ein ›erblick. (2 500 Wörter.)

1961 656 .281
:r Eisenbahningenieur, August, S. 238.
SCHÖNING (P.). — **Die mutmasslichen Ursachen** **i schwer aufzuklärenden Entgleisungen von zwei-** **hsigen leeren Güterwagen.** (Eine Ergänzung zu Heft 7/ 60.) (1 200 Wörter, Tabelle & Abb.)

E.T.R.-Eisenbahntechnische Rundschau. (Darmstadt.)

1961 656 (06 (43)
senbahntechnische Rundschau, Juli, S. 267.
KLITSCHER (R.). — **Die Deutsche Industrie-Messe** **annover 1961 und die Eisenbahntechnik.** Ein Messe- ·richt. (11 000 Wörter & Abb.)

1961 625 .123
senbahntechnische Rundschau, Juli, S. 289.
BETHÄUSER (A.). — Betrachtungen zur **Ent-** **ässerung und Stabilisierung des Bahnkörpers.** (4 000 'örter & Abb.)

1961 621 .335
isenbahntechnische Rundschau, Juli, S. 297.
LUDWIG (E.). — **Neue elektrische Triebfahrzeuge** ıd der bei ihnen erzielte Fortschritt. (7 000 Wörter . Abb.)

1961 625 .141
isenbahntechnische Rundschau, Juli, S. 309.
NAGEL (H.). — **Messverfahren zur Prüfung der** **leisbettung.** (5 500 Wörter & Abb.)

.T.Z. — Elektrotechnische Zeitschrift. (Berlin.)

1961 621 .314
.T.Z. Elektrotechnische Zeitschrift, 7. August, S. 430.
BODUROGLU (T.). — **Erhöhung der Lebensdauer** **ıd Belastbarkeit grösserer Öltransformatoren.** (675 Wör- :r & Abb.)

Europa Verkehr. (Darmstadt.)

1961 656
Europa Verkehr, Heft 2, S. 59.
KOTHER (H.). — **Verkehr und Forschung.** (1 400 Wörter.)

1961 656 .222 .6 (4)
Europa Verkehr, Heft 2, S. 70.
ZILLER (H.). — **TEEM-Trans-Europ-Express-Güter-** **züge.** (1 200 Wörter & Abb.)

1961 656 .226 (43)
Europa Verkehr, Heft 2, S. 72.
WENDLER (K.). — **Die Rationalisierung des Klein-** **gutverkehrs** bei der Deutschen Bundesbahn. (4 000 Wörter & Abb.)

1961 388 (42)
Europa Verkehr, Heft 2, S. 89.
STETZA (G.). — **Der öffentliche Verkehr in euro-** **päischen Grosstädten** — Beispiel London. (2 000 Wörter & Abb.)

1961 621 .335 (494)
Europa Verkehr, Heft 2, S. 92.
Die neuen elektrischen Mehrsystem-TEE-Züge der Schweizerischen Bundesbahnen (SBB). (1 000 Wörter & Abb.)

Internationales Archiv für Verkehrswesen. (Franfurt am Main.)

1961 656 .224
Intern. Archiv für Verkehrswesen, Juli, S. 220.
VOGEL (W.). — **Die moderne Eisenbahnreise.** (5 000 Wörter.)

Der Öffentliche Verkehr. (Bern.)

1961 656 .222 .5
Der Öffentliche Verkehr, August, S. 3.
FAHM (J.). — **Aufgaben und Probleme der Vororts-** **und Überlandbahnen** im Rahmen der Verkehrsentwicklung. (2 000 Wörter & Tabellen.)

Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik. (Zürich.)

1961 656 (494)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Heft 2, S. 105.
ZÜND (L.). — **Von der vertraglich gebundenen zur** **freien Konkurrenz im Güterverkehr Schiene/Strasse.** — Rückblick auf 8 Jahre GVV und Ausblick in die Zukunft. (4 000 Wörter, Tafeln & Abb.)

1961 656 .225 (44)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Heft 2, S. 142.
DELACARTE (L.). — **Les transports mixtes ferro-** **viaires et routiers en France.** (2 700 Wörter & Abb.)

1961 656 (494)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Heft 2, S. 153.
KALT (R.). — **Elemente zu einem schweizerischen Index des öffentlichen Verkehrs.** (1 400 Wörter & Tafeln.)

1961 656 .2 (66)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Heft 2, S. 163.
REICHEL (F.). — **Die Eisenbahnen in Nigerien.** (500 Wörter.)

Signal und Draht. (Frankfurt am Main.)

1961 656 .257
Signal und Draht, Juli, S. 97.
SIEBERS (H.). — Die Entwicklung der **Stromversorgungsanlagen für Stellwerke.** (3 000 Wörter & Abb.)

1961 656 .223 .2
Signal und Draht, Juli, S. 104.
SCHEPP (A.). — **Die Verwendung von Funksprecheinrichtungen im technischen Wagendienst.** (1 000 Wörter & Abb.)

1961 625 .162
Signal und Draht, Juli, S. 108.
WILMES (H.). — **Blinklichtanlage mit Halbschranken** regelt die Zugfolge einer Grubenbahn. (1 600 Wörter & Abb.)

Verkehr. (Wien.)

1961 656 (73)
Verkehr, Nr. 24, 17. Juni, S. 837.
LOWE (G.E.). — **Probleme des amerikanischen Verkehrswesens.** (1 800 Wörter.)

1961 656 (44)
Verkehr, Nr. 29, 22. Juli, S. 1033.
Tarifkoordinierung Schiene/Strasse in Frankreich bedingt neue Organisationsformen für Güterfernverkehr. (350 Wörter.)

In English.

British Transport Review. (London.)

1961 656 .2
British Transport Review, April, p. 159.
LANDON GOODMAN (L.). — **Automation and transport.** (4 800 words & figs.)

Bulletin, American Railway Engineering Association. (Chicago.)

1961 385 .061 .4 (73)
Bulletin, American Railway Engineering Association, No. 565, June-July, p. 741.
Proceedings. — Running report of the annual meeting of the A.R.E.A., held on March 7-9, at Chicago. (286 pages, illustrated.)

Electric Traction on the Railways. (Brussels.

1961 621 .31
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6 June, p. 255.
ALLE (J.P.). — Working principles of **transductors** (3 000 words & figs.)

1961 621 .331 (54
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6 June, p. 269.
RAO (B.V.S.). — Special features of 25 kV A.C **traction substations.** (4 800 words & figs.)

1961 621 .391 (73)
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6 June, p. 286.
Automation of motive power. (2 100 words & figs.)

1961 621 .333 (73)
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6 June, p. 294.
New York Central utilizes latest techniques. (800 words & figs.)

1961 621 .336 (47)
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6, June, p. 299.
Russian clamps for **overhead catenary.** (280 words & figs.)

1961 621 .335 (73)
Bulletin of the International Railway Congress Association — Electric Traction on the Railways, No. 6, June, p. 301.
Pennsylvania Railroad gets first new **electrics.** (480 words & figs.)

The Engineer. (London.)

1961 625 .144 (42) & 625 .173 (42)
The Engineer, July 7, p. 27.
Long rail handling train for London Transport. (400 words & figs.)

1961 621 .132 .1 (0
The Engineer, July 28, p. 124; Aug. 4, p. 180; Aug. 11 p. 227.
POULTNEY (E.C.). — **A locomotive history. — The « Atlantic ».** (15 000 words & figs.)

1961 625 .282 (42
The Engineer, July 28, p. 154.
Type-5 Diesel-electric locomotives. (1 500 words & figs.)

Ganz-Mávag Bulletin. (Budapest.)

1961 625 .2 (01

Ganz-Mávag Bulletin, May, p. 15.

GYÖRFFY (J.). — **Considerations at the strength calculation of railway car bodies.** (9 000 words, tables & figs.)

1961 625 .282

Ganz-Mávag Bulletin, May, p. 37.

VIZELYI (G.) and TÉBY (L.). — **Increasing the starting tractive force of locomotives.** (4 500 words & figs.)

1961 625 .215

Ganz-Mávag Bulletin, May, p. 60.

MINA (A.). — **Experiments with pneumatically spring bogies.** (3 000 words, tables & figs.)

Indian Railways (New Delhi.)

1961 625 .144 .1 (54)

Indian Railways, June, p. 353.

VENKATARAMAYYA (V.). — **Welding rail joints and track on Indian Railways.** (2 500 words & figs.)

Japanese Railway Engineering. (Tokyo.)

1961 625 .13 (52)

Japanese Railway Engineering, March, p. 36.

Construction of the new Tanna tunnel. (1 200 words & figs.)

1961 625 .172 (52)

Japanese Railway Engineering, June, p. 3.

MOTOYOSHI SHIBATA. — **New system of track maintenance.** (2 000 words & figs.)

1961 625 .4 (52)

Japanese Railway Engineering, June, p. 7.

TADASHI WAKIZAWA. — **Improvement of Abt-system section.** (2 000 words & figs.)

1961 656 .222 (52)

Japanese Railway Engineering, June, p. 14.

TAKASHI A KASHI. — **Why are JNR's trains punctual** ? (2 000 words & figs.)

Journal, The Institution of Locomotive Engineers. (London.)

1961 625 .282

Journal, The Institution of Locomotive Engineers, Vol. 50 (Part No. 6), Golden Jubilee Number, p. 617.

ROBERTSON (B.). — **The locomotive of the future.** (3 000 words.)

International Railway Journal. (The Hague.)

1961 621 .33 (45)

International Railway Journal, June, p. 18.

Electrification in Italy. (3 000 words & figs.)

1961 656 .2 (42)

International Railway Journal, June, p. 33.

B.R. modernization conference. (2 400 words & figs.)

1961 625 .23 (54)

International Railway Journal, June, p. 44.

India builds its own coaches. (1 600 words & figs.)

Mechanical Engineering. (New York.)

1961 656 .225 (71)

Mechanical Engineering, July, p. 52.

Side-loading piggyback. (300 words & figs.)

Mechanical Power. (London.)

1961 621 .431 .72 (42)

Mechanical Power, May, p. 101.

Twin-engined diesel shunter. (1 200 words & figs.)

1961 625 .282 (42)

Mechanical Power, July, p. 241.

English Electric type 3 locomotives. (1 000 words & figs.)

Modern Railroads. (Chicago.)

1961 656 .23 (73)

Modern Railroads, May, p. 76.

FORD (N.). — **« Scientific » rates win traffic.** (2 200 words & figs.)

1961 656 .25 (42)

Modern Railroads, May, p. 89.

DONNELLY (C.W.). — **D & H nears CTC goal.** (1 200 words & figs.)

1961 385 (061 .4 (73)

Modern Railroads, June, p. 77.

HAWTHORNE (J.W.). — **The AAR's role in mechanical progress.** (3 600 words & figs.)

Modern Transport. (London.)

1961 656 (493)

Modern Transport, June 17, p. 3.

POPPE (M.). — **Transport in Belgium.** (1 600 words.)

1961 656 .2 (42)

Modern Transport, June 17, p. 11.

The way ahead. — Prospects for British Railways. (1 200 words.)

1961 **625** .173 (71)
Modern Transport, June 24, p. 5.
Railway breakdown cranes for Canada. (1 600 words & figs.)

1961 **656** .28 (42)
Modern Transport, June 24, p. 7.
Electric train accidents and failures. (1 400 words.)

The Oil Engine. (London.)

1961 **621** .431 .72 (42)
The Oil Engine, June, p. 42.
2 500-HP locos. for British Railways. (2 000 words & figs.)

1961 **621** .431 .72 (42)
The Oil Engine, June, p. 46.
Type 2 locomotive experiences. (1 000 words & figs.)

1961 **621** .431 .72 (5)
The Oil Engine, June, p. 48.
Sound design brings repeat order. — Wickham train set for North Borneo. (1 000 words & figs.)

1961 **656** .2 (42)
The Oil Engine, June, p. 50.
Railway modernization conference. (700 words & tables.)

Railway Age. (New York.)

1961 **625** .245 (73)
Railway Age, June 12, p. 16.
NYC introduces new « Mark III » flexi-van design. (1 000 words & figs.)

1961 **625** .245 (73)
Railway Age, June 12, p. 41.
Phillips buys 30 300-Gal. tank cars. (300 words & figs.)

1961 **625** .14 (73)
Railway Age, July 3, p. 11.
NYCTA tels concrete roadbed. (600 words & figs.)

1961 **656** .212 .6 (73)
Railway Age, July 3, p. 14.
How new mail sorters help cut RR terminal costs. (800 words & figs.)

Railway Engineering. (Cape Town.)

1961 **625** .233 (68)
Railway Engineering, June, p. 19; July, p. 39.
ROHMAN (J.R.). — **The development of lighting in railway coaches** (*to be continued*). (4 500 words & figs.)

1961 **621** .133 .7
Railway Engineering, June, p. 26.
New life for steam locomotives. — Good results bring large orders for Giesl ejectors. (1 500 words & figs.)

1961 **625** .282
Railway Engineering, July, p. 21.
Differential transmission in new prototype 600 HP Diesel locomotive. (700 words & figs.)

1961 **625** .232 (68)
Railway Engineering, July, p. 25.
Main line steel passenger coaches for the South African Railways. (1 800 words & figs.)

Railway Electrification. (Calcutta.)

1961 **621** .33 (54)
Railway Electrification, Vol. 2, Nos. 1-2, p. 14.
SANKARANARAYANAN (C.A.). — **Development of cantilever assemblies for 25 kV overhead equipment.** (6 500 words & figs.)

The Railway Gazette. (London.)

1961 **625** .142 .4 (73)
The Railway Gazette, June 30, p. 735.
Casting the MR-I sleeper by automation. (200 words.)

1961 **621** .338 (42)
The Railway Gazette, June 30, p. 736.
New rolling stock for London Transport. (2 600 words & figs.)

1961 **621** .335 (44)
The Railway Gazette, June 30, p. 742.
High speed trials on S.N.C.F. (600 words & figs.)

1961 **656** .25 (42)
The Railway Gazette, July 7, p. 10.
Re-signalling at Newport, Western Region. (1 500 words & figs.)

1961 **656** .25 (42)
The Railway Gazette, July 7, p. 17.
Signalling developments on London Transport. (600 words & figs.)

1961 **625** .144 (42) & **625** .173 (42)
The Railway Gazette, July 7, p. 18.
Long welded rail train for London Transport. (1 200 words & figs.)

1961 **621** .431 .72 (42) & **625** .282 (42)
The Railway Gazette, July 14, p. 42.
Type 3 locomotive for British Railways. (900 words & figs.)

1961 **656** .212 .5 (42)
The Railway Gazette, July 14, p. 45.
Marshalling yard at Lamesley in the North Eastern Region. (1 600 words & figs.)

1961 **625** .282 (42) & **621** .431 .72 (42)
The Railway Gazette, July 21, p. 69.
Diesel-hydraulic locomotives for the Western Region of British Railways. (1 000 words & figs.)

Diesel Railway Traction. (London.)

1961 **621** .431 .72 (42)
Diesel Railway Traction, June, p. 211.
1 750 HP Diesel-electric locomotives. (1 500 words & figs.)

1961 **621** .431 .72 (492)
Diesel Railway Traction, June, p. 215.
Automatic coupler in the Netherlands. (1 400 words & figs.)

1961 **621** .431 .72 (42)
Diesel Railway Traction, June, p. 233.
Diesel power on British Railways. (7 000 words, tables & figs.)

1961 **621** .431 .72 (42)
Diesel Railway Traction, July, p. 251.
Diesel power on British Railways. (2 000 words, table & figs.)

Railway Signaling and Communications. (New York.)

1961 **65** (73)
Railway Signaling and Communications, July, p. 13.
Car data moves fast via ... D & RGW microwave and fax. (2 000 words & figs.)

1961 **625** .214 (73)
Railway Signaling and Communications, July, p. 23.
Seaboard Air Line has talking hotbox detector. (300 words & figs.)

In Spanish.

Boletin de la Comisión Permanente de la Asociación del Congreso Panamericano de Ferrocarriles. (Buenos Aires.)

1961 **625** .142 .2 (73)
Bol. de la Com. Perman. de la Asociación del Congreso Panameric. de Ferrocarriles, marzo-abril, p. 62.
Estados Unidos de America. — **El futuro de los durmientes de madera.** — Convención de la RTA. (2 000 palabras.)

1961 **385** .511 (73)
Bol. de la Com. Perman. de la Asociación del Congreso Panameric. de Ferrocarriles, marzo-abril, p. 72.
RODDEWIG (C.M.). — **Modernización de los contratos del trabajo ferroviario.** (3 200 palabras.)

Revista de Ciencia Aplicada. (Madrid.)

1961 **691**
Revista de Ciencia aplicada, julio-agosto, p. 298.
CALLEJA (J.). — **Equivalencia aproximada entre las resistencias a la compresión de los morteros de cemento de Portland según las distintas normas.** (3 000 palabras, tablas & fig.)

Revista de Obras Publicas. (Madrid.)

1961 **624**
Revista de Obras Publicas, julio, p. 525.
LAFFITTE MESA (C.). — **Resolución de estructuras reticuladas planas por una analogia electrica.** (3 000 palabras, cuadros & fig.)

In Italian.

Giornale del Genio Civile. (Roma.)

1961 **62** (01
Giornale del Genio Civile, giugno, p. 457.
ZANABONI (O.). — Premesse allo **studio della stabilità dell'equilibrio elastico.** (9 000 parole & fig.)

Ingegneria Ferroviaria. (Roma.)

1961 **621** .438
Ingegneria Ferroviaria, giugno, p. 487.
BRUTTI (C.). — **Il progetto dei dischi sollecitati elasticamente nei turbomotori termici.** (5 000 parole, tabelle & fig.)

1961 **62** (01
Ingegneria Ferroviaria, giugno, p. 504.
POLSONI (G.). — **Sostituzione di un carico continuo con carichi discreti** (concentrati). — Carichi nodali. (1 000 parole, tabella & fig.)

1961 **621** .33 (45)
Ingegneria Ferroviaria, giugno, p. 507.
PROSPERI (L.). — **Applicazioni dei telecomandi, dei telecontrolli e delle telemisure agli impianti fissi T.E.** delle linee siciliane. (6 000 parole & fig.)

1961 **656** .2 (485)
Ingegneria Ferroviaria, giugno, p. 521.
INTRONA (S.). — **Struttura e funzionalità delle ferrovie svedesi.** (6 000 parole, tabelle & fig.)

1961 **385** .587
Ingegneria Ferroviaria, giugno, p. 541.
DODET (V.). — **Efficienza e produttività degli impianti.** (2 500 parole.)

Politica dei Trasporti. (Roma.)

1961 **656**
Politica dei Trasporti, maggio, p. 214.
PINTO (G.). — **I trasporti e lo sviluppo economico.** (2 800 parole.)

1961 **656** .225 (47)
Politica dei Trasporti, maggio, p. 238.
LOZZI (C.). — **I trasporti ferroviari merci in Russia.** (1 200 parole.)

1961 **625** .42 (43)
Politica dei Trasporti, maggio, p. 242.
L'ampliamento della ferrovia rapida urbana (S-Bahn) di Amburgo. (1 800 parole & fig.)

1961 **656** .25
Politica dei Trasporti, giugno, p. 266.
OMODEI (A.). — Il Simposio sul **controllo della sicurezza ferroviaria.** — Genova, 17-19 giugno 1961. (1 800 parole.)

Trasporti Pubblici. (Roma.)

1961 **656** .25 : **625** .42 (45)
Trasporti Pubblici, gennaio-febbraio, p. 61.
CURTI (C.). — Memoria sull'estensione **dell'impianto di telecomando delle sottostazioni della metropolitana alle sottostazioni e posti di sezionamento di linea aerea** della ferrovia Roma-Lido della S.T.E.F.E.R. (2 400 parole & fig.)

1961 **625** .13 (45)
Trasporti Pubblici, gennaio-febbraio, p. 73.
Ponte subacqueo nello Stretto di Messina. (1 500 parole & fig.)

1961 **656** .1 & **656** .2
Trasporti Pubblici, gennaio-febbraio, p. 81.
Il « Roadrailer », nuovo semirimorchio « stradarotaia ». (400 parole & fig.)

1961 **621** .33 (45)
Trasporti Pubblici, gennaio-febbraio, p. 87.
La trazione elettrica sulla Mestre-Udine. (2 100 parole & fig.)

1961 **621** .335 (44)
Trasporti Pubblici, gennaio-febbraio, p. 95.
La locomotiva elettrica BB 9400 a corrente continua a 1 500 V della S.N.C.F. (3 700 parole & fig.)

1961 **625** .42 (47)
Trasporti Pubblici, gennaio-febbraio, p. 105.
La metropolitana di Kiew. (250 parole & fig.)

1961 **625** .245 (45)
Trasporti Pubblici, marzo-aprile, p. 227.
Il nuovo carro F.S. per il trasporto di automobili. (1 000 parole & fig.)

1961 **656** .25 (42)
Trasporti Pubblici, marzo-aprile, p. 229.
VENNING (C.F.D.). — **Nuovi sistemi di segnalazioni** per le Ferrovie Inglesi. (1 500 parole & fig.)

1961 **621** .33 (42)
Trasporti Pubblici, marzo-aprile, p. 235.
WILLIAMS (A.L.). — **Un laboratorio di ricerche studia i problemi della trazione elettrica** nelle Ferrovie Inglesi. (1 000 parole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1961 **654**
De Ingenieur, nr 30, 28 juli, p. E. 47.
Multitooncodesignaleringssysteem. V. **Transmissie-technische aspecten van het systeem,** door F.W. HÖLD. (2 000 woorden & fig.). — VI. **De invoering in het Nederlands net,** door J.N.A. van POETEREN. (2 000 woorden & fig.)

1961 **691**
De Ingenieur, nr 30, 28 juli, p. Bt. 87.
HARRIS (A.J.). — **Triangulated prestressed concrete beams.** (3 200 woorden & fig.)

1961 **621** .3
De Ingenieur, nr 30, 28 juli, p. E. 57.
HANNESEN (H.). — **Gedrukte bedradingen.** (2 000 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1961 **385** (07 .4 (493)
Spoor- en Tramwegen, nr 14, 13 juli, p. 225.
JACOPS (A.). — **Het Belgische Spoorwegmuseum te Brussel.** (900 woorden & fig.)

1961 **385** (09 (48)
Spoor- en Tramwegen, nr 14, 13 juli, p. 231.
STUNNENBERG (J.). — **De ijzeren weg in het land der duizend meren.** (1 300 woorden, tabellen & fig.)

1961 **385** (09 (73)
Spoor- en Tramwegen, nr 14, 13 juli, p. 236.
De spoorwegen in de U.S. (800 woorden.)

1961 **656** .222
Spoor- en Tramwegen, nr 15, 27 juli, p. 241.
VERBEEK (J.L.). — **Gelijktijdig mogelijke treinbewegingen tussen twee sporenbundels en de daartoe vereiste wisselgroep.** (1 500 woorden & fig.)

1961 **656** .222 .5 (44)
Spoor- en Tramwegen, nr 15, 27 juli, p. 243.
VAN DEN DOOL (W.H.). — **Le Mistral.** (*Slot.*) (2 000 woorden & fig.)

1961 **656** .2 (42)
Spoor- en Tramwegen, nr 15, 27 juli, p. 246.
« The way ahead » voor de Britse Spoorwegen. (1 300 woorden.)

1961 **625** .245
Spoor- en Tramwegen, nr 15, 27 juli, p. 248.
HUPKES (G.). — Waar komen de **speciale wagens** vandaan ? **Tendensen in de goederenwagenbouw.** (1 000 woorden & fig.)

1961 621 .431 .72
…oor- en Tramwegen, nr 15, 27 juli, p. 249.
Een blik in de toekomst ... **het rijk van de diesel.** 500 woorden & fig.)

In Polish (= 491 .85).

Przeglad Kolejowy Drogowy. (Varsovie.)

1960 625 .172 (438) = 491 .85
…rzeglad Kolejowy Drogowy, janvier, p. 9.
PYTLAK (S.). — **Moyens de désherbage** et leur …pplication aux P.K.P. (2 200 mots & fig.)

1960 625 .142 .4 = 491 .85
…rzeglad Kolejowy Drogowy, janvier, p. 13.
ZAJKOWSKI (Z.). — Construction de la **voie sur …averses en béton armé.** (1 400 mots.)

1960 624 .1 = 491 .85
…rzeglad Kolejowy Drogowy, février, p. 21.
SERWONSKI (F.). — **Protection des piles de pont …ontre l'affouillement.** (1 800 mots & fig.)

1960 624 .63 = 491 .85
…rzeglad Kolejowy Drogowy, février, p. 32.
OTFINOWSKI (S.). — **Ponts ferroviaires en béton …récontraint.** (2 000 mots & fig.)

1960 625 .143 .4 = 491 .85
…rzeglad Kolejowy Drogowy, mars, p. 41.
ZAMIECKI (H.). — **Pose et entretien de la voie …ans joints** du type thermique tendu. (1 600 mots & fig.)

1960 625 .13 = 491 .85
Przeglad Kolejowy Drogowy, mars, p. 51.
SOCHACKI (K.). — Etanchéité hydraulique et **…ventilation des tunnels ferroviaires.** (1 500 mots & fig.)

1960 624 .2 = 491 .85
Przeglad Kolejowy Drogowy, avril, p. 61.
KORELESKI (J.). — **Mesure des fléchissements de ponts.** (1 000 mots & fig.)

1960 625 .143 = 491 .85
Przeglad Kolejowy Drogowy, mai, p. 82.
LANKIEWICZ (J.). — **Aménagements des changements des rails de la voie en barres longues.** (1 600 mots & fig.)

1960 656 .225 = 491 .85
Przeglad Kolejowy Drogowy, juin, p. 101.
KLYSZ (J.). — **Moyens de transport pour les travaux de construction.** (3 100 mots & fig.)

1960 625 .143 .4
Przeglad Kolejowy Drogowy, juin, p. 116 (suite dans les numéros d'août et de septembre).
NEKANDA-TREPKA (L.). — **Application de la soudure aluminothermique** dans les assemblages de rails dans les barres longues aux P.K.P. (4 600 mots & fig.)

Przeglad Kolejowy Elektrotechniczny. (Varsovie)

1960 621 .31 = 491 .85
Przeglad Kolejowy Elektrotechniczny, janvier, p. 15.
GODWOD (J.). — **Répéteurs intermédiaires à transistors** sur les lignes à courants porteurs, modèle COB i RTK, Varsovie. (1 300 mots & fig.)

1960 621 .332 (438) = 491 .85
Przeglad Kolejowy Elektrotechniczny, janvier, p. 20.
LEWINSKI (J.). — **Régulation des sous-stations de traction** du nœud ferroviaire de Gdansk (Dantzig). (1 500 mots & fig.)

1960 656 .257 = 491 .85
Przeglad Kolejowy Elektrotechniczny, février, p. 42.
GRYGLEWICZ (J.). — **Relais employés dans les appareillages de commande de l'installation de télécommande centralisée.** (2 200 mots & fig.)

1960 656 .223 .2 = 491 .85
Przeglad Kolejowy Elektrotechniczny, février, p. 52.
SUCHODOLSKI (J.). — **Relevés de wagons confectionnés à l'aide de moyens de télécommunications à sens unique.** (1 600 mots & fig.)

1960 621 .335 = 491 .85
Przeglad Kolejowy Elektrotechniczny, mars, p. 140.
DZIUBA (W.). — Perspectives de développement des **locomotives électriques à courant alternatif monophasé 50 Hz.** (1 400 mots, tableaux & fig.)

1960 621 .331 = 491 .85
Przeglad Kolejowy Elektrotechniczny, mars, p. 78.
SOBIERAJ (K.). — **Nouvelles sous-stations de traction transportables** aux P.K.P. (1 800 mots & fig.)

1960 621 .39 = 491 .85
Przeglad Kolejowy Elektrotechniczny, mars, p. 83.
BLASZKOWSKI (J.). — **Nouvel appareil de contrôle des cadrans d'appel.** (500 mots & fig.)

1960 621 .33 (438) = 491 .85
Przeglad Kolejowy Elektrotechniczny, avril, p. 97; juin, p. 162.
MANKO (Z.). — **Traction électrique aux P.K.P.** en 1950-1960. (2 500 mots & fig.)

1960 654 = 491 .85
Przeglad Kolejowy Elektrotechniczny, avril, p. 106.
BUCZKOWSKA (T.). — Nouvel appareil oscilloscopique pour **le contrôle des relais télégraphiques.** (1 900 mots & fig.)

1960 656 .259 = 491 .85
Przeglad Kolejowy Elektrotechniczny, mai, p. 132.
KALICINSKA (K.). — **Modèle universel d'une section de voie isolée.** (1 500 mots & fig.)

1960 621 .3 : 656 .2 = 491 .85
Przeglad Kolejowy Elektrotechniczny, mai, p. 148; juin, p. 185.
KOZLOWSKI (A.). — **Application des calculateurs électroniques dans l'automatisation du trafic ferroviaire.** Méthode de leur travail. (3 300 mots & fig.)

1960 **621** .3 : **656** .25 = 491 .85
Przeglad Kolejowy Elektrotechniczny, juin, p. 170.
PIASTOWSKI (J.). — **Application de l'électronique aux différents dispositifs de signalisation.** (1 400 mots & fig.)

1960 **621** .33 (438) = 491 .85
Przeglad Kolejowy Elektrotechniczny, juin, p. 178.
ADAMIAK (S.). — **Le réseau de traction électrique aux P.K.P. en exploitation.** (2 000 mots & fig.)

In Portuguese.

Boletim da C.P. (Lisboa.)

1961 **656**
Boletim da C.P., julho, p. 3.
FARIA LAPA (J.). — **Reacçâo necessária.** (1 600 palavras.)

1961 **659**
Boletim da C.P., julho, p. 9.
de ALBUQUERQUE (C.S.). — **Relaçôes públicas** e publicidade nos caminhos de ferro. (2 000 palavras.)

1961 **625** .143 .4
Boletim da C.P., julho, p. 35.
RIBEIRO (A.). — **Soldadura de carris** « par étincelage ». (1 000 palavras & fig.)

Revista Ferroviária. (Rio de Janeiro.)

1961 **621** .131 .1
Revista Ferroviária, julho, p. 29.
A operaçâo ferroviária em face da **melhoria da aderância.** (1 500 palavras.)

1961 **625** .42 (42)
Revista Ferroviária, julho, p. 31.
Novos trens para o Metropolitano de Londres. (900 palavras & fig.)

1961 **621** .35
Revista Ferroviária, julho, p. 32.
Acumuladores elétricos para traçâo. (600 palavras.)

1961 **625** .42 (73)
Revista Ferroviária, julho, p. 53.
Novos carros para o subterrâneo de Nova York. (300 palavras & fig.)

Revista do Sindicato Nacional dos Engenheiros auxiliares, agentes técnicos de Engenharia e Condutores. (Lisboa.)

1961 **694**
Rev. do Sindicato Nac. dos Engenheiros auxiliares, agentes técnicos de Engenharia e Condutores, jan./março, p. 34.
MATEUS (T.J.E.). — **Protecçâo das madeiras das construçôes** contra fungos e insectos xilófagos. (5 000 palavras.)

Técnica. (Lisboa.)

1961 **669** .1
Técnica, junho, p. 569.
SORETZ (S.). — **A evoluçâo até ao aço nervurado** « TOR ». (5 000 palavras & fig.)

In Russian (= 491 .7).

Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Instituta Jelesno-Doroznowo Transporta. (Moscou.)

1960 **656** .225 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Institouta Jelesno-Doroznowo Transporta, nº 3, p. 3.
BOUCHÉ (N.A.). — Perspectives des recherches scientifiques dans le domaine d'économie en **transport ferroviaire des métaux non-ferreux.** (2 600 mots & fig.)

1960 **656** .212 .9 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Institouta Jelesno-Doroznowo Transporta, nº 3, p. 12.
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1960 **621** .431 .72 = 491 .7
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1960 **621** .3 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Institouta Jelesno-Doroznowo Transporta, nº 3, p. 22.
SOKOLOV (S.D.). — **Localisation des courants de perturbation en suite aux arcs en retour et aux court-circuits.** (2 500 mots & fig.)

1960 **621** .431 .72 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Institouta Jelesno-Doroznowo Transporta, nº 3, p. 27.
MAYSEL (L.M.), TCHERNOMORDIK (B.M.) et ISSAYÉV (L.A.). — **Application des générateurs à gaz à pistons libres dans des installations de locomotives.** (2 700 mots & fig.)

1960 **625** .2 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyélskowo Institouta Jelesno-Doroznowo Transporta, nº 3, p. 32.
POPOV (A.A.). — **Détermination de la réserve de stabilité des essieux pour les régimes de chargement non-stationnaires.** (2 100 mots & fig.)

1960 **625** .212 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 3, p. 36.
DOUVALYANE (S.V.). — Détermination analytique **des tensions dans le disque d'une roue monobloc.** (1 900 mots & fig.)

1960 **625** .143 .3 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 3, p. 40.
ANDRYÉVSKY (S.M.). — **L'usure latérale des champignons de rails dans les courbes.** (3 100 mots & fig.)

1960 **654** = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 3, p. 46.
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1960 **625** .282 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 3, p. 54.
MINTCHÉNKO (N.I.) et TYOUTINE (W.I.). — Prolongation de la durée de service de la **transmission par engrenages de locomotives.** (1 100 mots & tableaux.)

1960 **621** .332 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 3.
BYTCHKOVSKY (A.V.). — **Réduction de la consommation d'énergie électrique dans la traction des trains.** (2 200 mots & fig.)

1960 **654** = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 7.
WAKHNINE (M.N.). — **Protection contre les surtensions** dans les installations de télécommunications et d'automatisme employant des éléments semi-conducteurs. (1 800 mots & fig.)

1960 **625** .28 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 10.
DROSDOV (N.A.) et TCHÉBYKINE (W.N.). — L'amélioration de **l'utilisation des locomotives électriques et des locomotives Diesel dans le trafic voyageurs.** (2 100 mots & fig.)

1960 **621** .335 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 18.
TOUCHKANOV (B.A.). — **Amélioration et simplification des schémas électriques des locomotives à courant continu.** (1 500 mots & fig.)

1960 **621** .116 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 25.
MÉTAXA (V.A.). — Particularités des **méthodes de calcul thermique des chaudières fixes.** (1 600 mots & tableaux.)

1960 **621** .431 .72 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 31.
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1960 **625** .14 = 491 .7 & **625** .2 = 491 .7
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1960 **625** .212 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 37.
GOLOUTVINA (T.K.). — **L'usure des bandages des roues de wagons.** (2 400 mots & fig.)

1960 **625** .143 .3 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 42.
MYÉLENTYÉV (L.P.). — **Modification par suite d'usure de la forme des champignons des rails extérieurs dans les courbes.** (1 100 mots & fig.)

1960 **625** .141 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 44.
CHAFRANOVSKY (A.K.) et WINOGRADOV (Y.G.). — Méthode d'examen à l'aide de rayons X du **travail de la couche de ballast.** (2 500 mots & fig.)

1960 **625** .151 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 4, p. 47.
YACOVLEV (W.F.). — **Sur la stabilité de contact des éléments des circuits de voie dans l'appareil de manœuvre d'aiguille.** (1 900 mots & fig.)

1960 **669** = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Issiédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 7.
CHTCHAPOV (N.P.). — **Réserves d'économie des méteaux ferreux en transport ferroviaire.** (2 900 mots.)

1960 656 .212 .5 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 12.
KORCHE (W.B.). — **Exigences principales d'exploitation et de technique pour les petits sabots-freins.** (2 700 mots & fig.)

1960 656 .257 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 17.
OVLASIOUK (V.Y.) et PRONINE (A.N.). — Groupes élémentaires (sous-appareillage) typiques d'automatique et de la commande à distance dans les **appareils à semi-conducteurs.** (2 400 mots & fig.)

1960 656 .223 .2 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 23.
KOVCHOV (G.N.) MOKROOUSOVA (N.I.) et NESTYÉROV (E.P.). — **Calcul des courants de wagons planifiés** avec l'aide d'un calculateur électronique. (1 300 mots & fig.)

1960 621 .438 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 29.
BARTOCHE (E.T.). — Les caractéristiques de traction de la **turbine à gaz.** (2 100 mots & fig.)

1960 621 .438 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 33.
KOVALEV (E.A.). — **Corrosion des aubes de turbine de la locomotive à turbine à gaz** lors de la combustion d'un combustible liquide lourd. (2 500 mots & fig.)

1960 656 .222 .1 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 38.
GOURSKY (P.A.) et KORNYÉV (N.N.). — Méthode pour construire la **courbe de vitesse relative aux sections de longues pentes.** (2 400 mots & fig.)

1960 625 .141 = 491 .7
Viésstnik Vssésoïousnowo Naoutchno-Isslédowatyél-skowo Institouta Jelesno-Doroznowo Transporta, n° 5, p. 42.
TZIGUÉLNY (P.M.). — **Détermination de la compacité du ballast de gravier** à l'aide d'isotopes radioactifs. (1 800 mots & fig.)

In Czech. (= 91 .886).

Inženýrské Stavby. (Prague.)

1961 691 = 91 .886
Inženýrské Stavby, juillet, p. 267.
KLAPETEK (F.). — **Calcul des contraintes de retrait dans les constructions en béton armé.** (2 500 mots & fig.)

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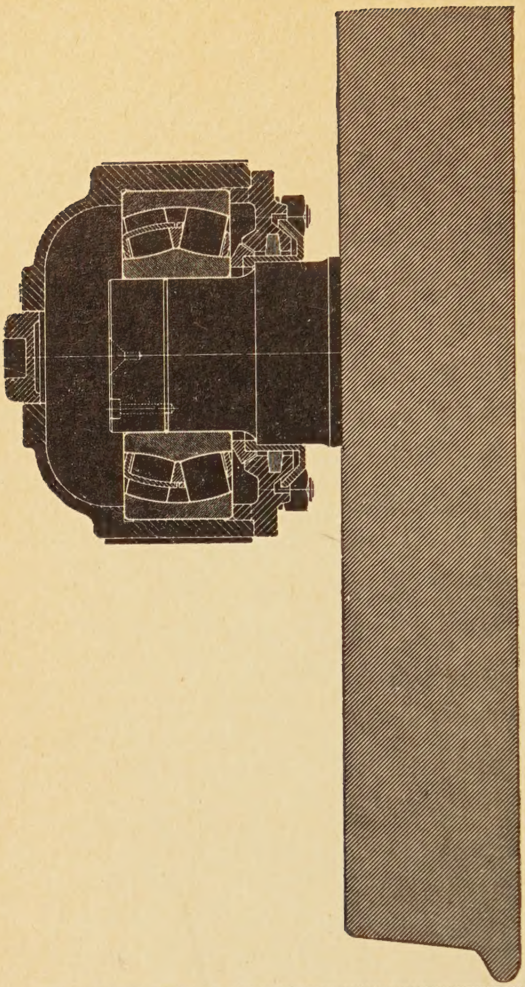

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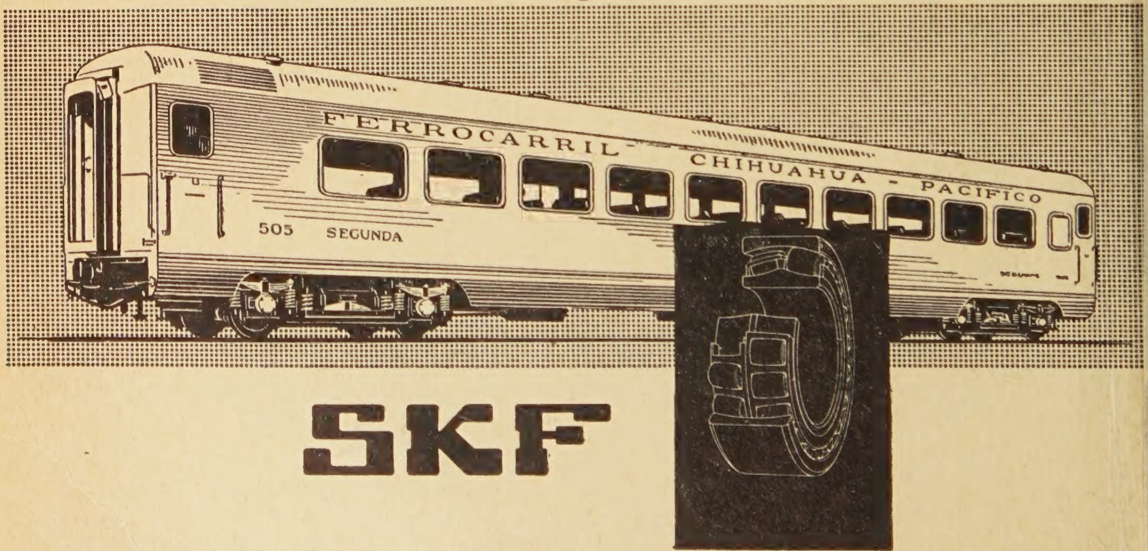

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